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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

APRIL 1960

SPECIAL ASTRONAUTICS REPORT:
OBSERVATION SATELLITES

Plug Nozzle: New Approach to Engine Design . . . Kurt Berman
Multistart Rocket Engines . . . . . Kurt R. Stehling
Composition of Outer Space . . . . . Francis S. Johnson

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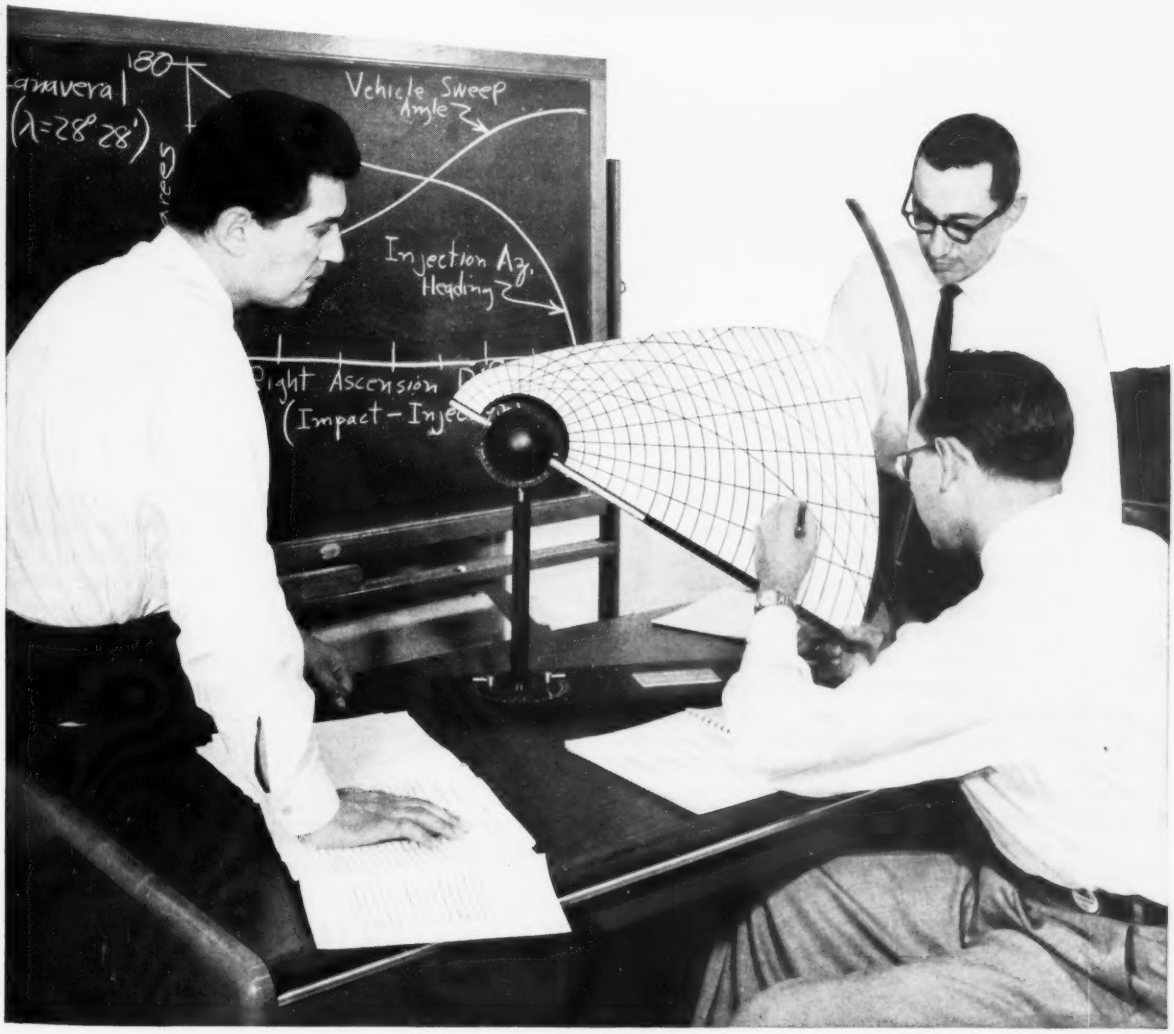

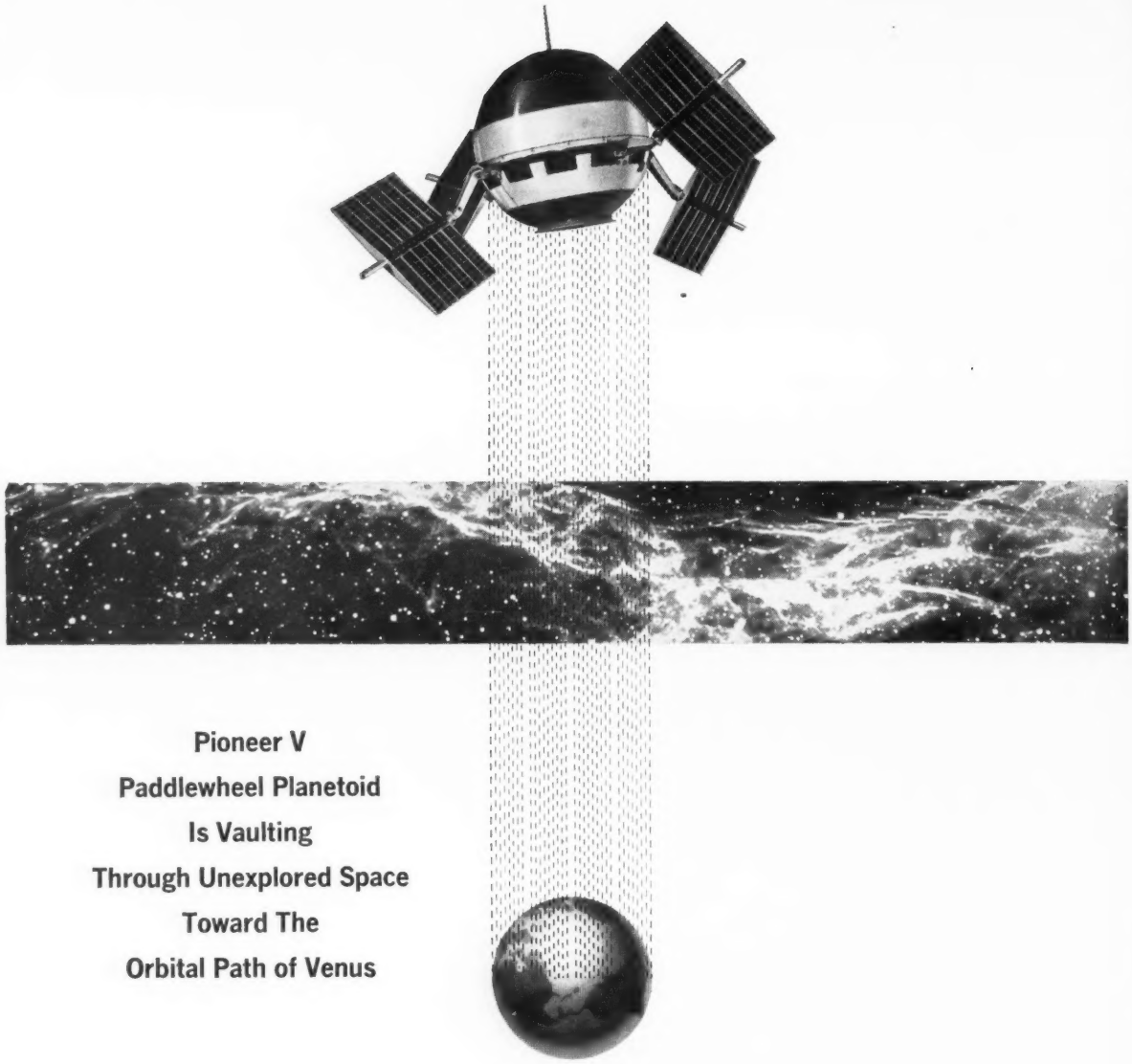

Pioneer V
Paddlewheel Planetoid
Is Vaulting
Through Unexplored Space
Toward The
Orbital Path of Venus

At this moment Pioneer V, one of the most advanced space probe vehicles ever launched, is on a course toward the path of Venus—26 million miles from earth. Blasted aloft March 11 by a Thor Able-4 rocket booster, this miniature space laboratory will reach its destination in about 130 days.

The project, carried out by Space Technology Laboratories for the National Aeronautics and Space Administration under the direction of the Air Force Ballistic Missile Division, may confirm or disprove long-standing theories of the fundamental nature of the solar system and space itself.

Energy from the sun—captured by almost 5,000 cells mounted in the four paddles—is used to supply all of the electrical power to operate the sophisticated array of instrumentation packed into the 94-pound spacecraft which measures only 26″ in diameter.

By combining a phenomenal digital electronic brain (telebit) with a powerful radio transmitter inside the satellite, STL scientists and engineers expect to receive communications from Pioneer V at their command over interplanetary distances up to 50 million miles.

STL's technical staff brings to this space research the same talents which have provided over-all systems engineering and technical direction since 1954 to the Air Force missile programs including Atlas, Thor, Titan, Minuteman, and related space programs.

Important positions in connection with these activities are now available for scientists and engineers with outstanding capabilities. Inquiries and resumes are invited.

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Astronautics

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Astro notes

PATHFINDER TO VENUS

• Pioneer V, a paddlewheel interplanetary probe developed by STL for NASA, made its debut March 11, launched successfully from Cape Canaveral into a heliocentric orbit lying between Earth's and Venus'. The new U.S. planetoid will have a year of 311.6 days. Pioneer V weighs 94.8 lb and measures 26 in. in diam, discounting the four extended paddlewheels loaded with 4800 solar cells. It employs a version of STL's Telebit navigation and communication system and basic experiments on space radiation, magnetic fields, plasmas, micrometeorites, and solar flares. The Telebit uses a 5-watt transmitter to signal out to several million miles and then to preamplify a 150-watt command transmitter that NASA hopes to track to at least a distance of 30 million miles. With the new planetoid responding to interrogation at a record distance of 407,000 miles on March 14, hopes are high that Pioneer V will be a jackpot space experiment. In particular, triangulation of signal plots from it should provide a new measure of the astronomical unit, now known only to plus or minus 50,000 miles, and thus pave the way for really accurate trajectories in coming probes to the Moon, Mars, and Venus.

LAUNCHING NOTES

• Major launching events crowd the space agenda in the next two months, after a long, cold winter. The first Tiros shot was expected toward the end of March . . . A Delta packing an Echo inflatable sphere is scheduled for April 15 or thereabouts . . . The first Scout launching, expected in March, will not be attempted until May; and, if problems with its third stage controls are not solved by then, may be put off until June or July . . . The first launching of an unmanned Mercury capsule on an Atlas booster should take place in May. . . . There will be a Javelin shot in May with a magnetometer experiment.

• A lunar probe, using an Atlas-Able, is now not expected until some time in July, and then again in October . . . A second Delta with Echo sphere comes up for launching in July . . . Hard lunar impact attempts with Delta are being considered for later in the year . . . The modified Redstone may take an ape for a ballistic flight in a Mercury capsule by early autumn.

MAN IN SPACE

• At the same time it is qualifying the Mercury capsule for its first human passenger on a 200-mile Redstone shot, NASA will conduct a series of rigorous capsule flight-tests using the Atlas vehicle. Three trajectories are planned: Maximum abort conditions with a 19-g re-entry achieved by plunging the capsule steeply back into the atmosphere from an altitude of 140 miles; duplication of the planned 8-g re-entry in a 2000-mile shot from an altitude of 90 miles; and insertion of the capsule into orbit with immediate turnaround and 8-g re-entry from 120 miles' altitude over a range of 4000 miles. All Atlas flights will be unmanned, although chimpanzees may be used in the second or third type of trajectory.

• For the orbital flights, NASA expects one fully instrumented flight (without animal) and one flight with a chimp before it commits an Astronaut to the system. Extra safety precautions during the initial moments after orbital launching include the designation of five emergency landing areas in the Atlantic where ships will be stationed to retrieve the capsule. Emergency landing areas will also be provided after completion of the first and second orbits.

• Minneapolis-Honeywell has announced the development of an Earth Path Indicator to show the Mercury pilot where he is at any point during flight in the event he loses contact with ground stations and must re-enter. The indicator will present a revolving globe to the Astronaut and will show his impact point when ejected from orbit. The device must be set by the Astronaut when he reaches orbit, using information relayed from ground tracking stations.

• The AF will provide a Boeing KC-135 jet tanker to the Aero-Medical Laboratory, WADC, for weightlessness studies. With its greater speed, the jet will be able to produce more than 35 sec of weightlessness in a Keplerian parabola, more than double the time allowed by the Convair-340 now in use. In addition to gathering biomedical information, Boeing says, the AF may want to run its Dynasoar test pilots through zero-g flights. It also suggested a variety of important engineering studies involving the handling of liquids in zero-g, including pressure sensing, venting, boiling, condensing, and refrigeration in situations where a combined liquid-vapor phase may exist.

• Looking down the road a number of years, Ira Abbott, NASA's director of advanced research programs, foresees a Saturn-launched space station with a diameter of 40 ft and a total weight of 12,000 to 15,000 lb. Power will be supplied by a solar-heated boiler and turbo-generator. Rotating at 6 rpm, the station would provide $^1/_4$ g at its rim—possibly a necessity if man is to occupy it for periods of several weeks. The station would erect itself automatically, and men would be rocketed up from earth to occupy it.

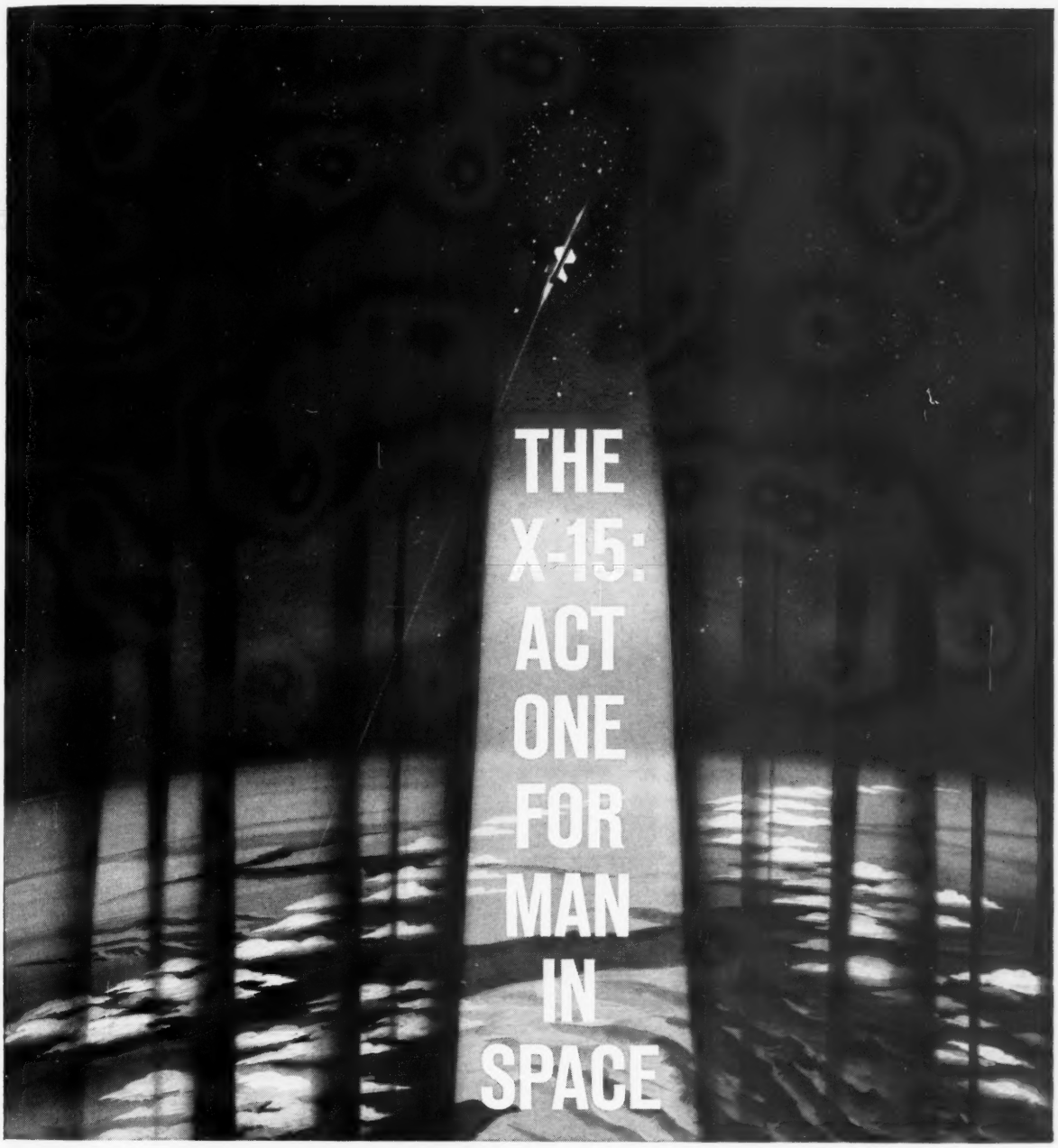
• The Space Ecology Branch of the AF School of Aviation Medicine has run the first shakedown test of its two-man space-cabin simulator, which was delivered last fall by Minneapolis-Honeywell's Aeronautical Div. The unique chamber will soon be very active in a schedule of simulated manned spaceflights.

• The environmental test chamber being built by Tenney Engineering for NASA will be situated at Cape Canaveral for testing the Mercury capsule with Astronaut in simulated descents from 225,000-ft pressure altitude.

NUCLEAR PROPULSION

• After the Budget Bureau refused the AEC certain requested funds, amounting to some $11 million, for the Project Rover nuclear-rocket program, the atom agency decided it could dig up the money itself, by limiting new construction at its testing grounds in Nevada and Eniwetok atoll in the Pacific and by cutting its proposed budget for the slow-moving Euratom program in Western Europe. The AEC believes its new funding plan, which will put $21 million behind Rover during the coming fiscal year, will make it possible to demonstrate the feasibility of a solid-core nuclear-rocket engine by 1963.

The realignment of funds was announced by the AEC in a hear-



As North American's X-15 – world's most advanced manned research craft–parts the curtain of earth's atmosphere, the arts of guidance and direction must play a critical role. Sperry's Air Armament Division, assigned the Flight Data System responsibility for the X-15, is meeting the challenge with inertial guidance gear of advanced design, precision and dependability.

But the problems of inertial guidance are not new to Sperry. During the past ten years, over 25-million Sperry man-hours have been employed to develop and produce successful inertial guidance. As a result, the nation has in the Convair B-58 Hustler the most thoroughly studied, analyzed, tested, evaluated and understood inertial guidance system in being – plus the advanced guidance equipment for the X-15 and for other future applications.

And in addition to work on government sponsored space guidance systems and techniques, Sperry scientists and engineers are exploring new and exotic techniques for gyros, advanced miniaturized digital computers, acceleration sensors, zero gravity environment systems–in many cases involving radical departures from current technology–with the aim of developing concepts, systems and hardware that are *ahead* of the challenges of man in space.

SPERRY

AIR ARMAMENT DIVISION, SPERRY GYROSCOPE COMPANY, DIVISION OF SPERRY RAND CORPORATION, GREAT NECK, NEW YORK

ing early in March before the Joint Congressional Committee on Atomic Energy, which has been trying to accelerate the Rover program. It will be difficult for NASA to plan for actual adaptation of the prototype Rover engine for flight-testing until the AEC believes it has demonstrated a sound working engine. Meanwhile, it looks as if criticism directed at NASA for assertedly not pushing Project Rover might rebound on the AEC, which still holds all of the strings in developing the rocket.

• Brig. Gen. Irving L. Branch, USAF, director of AEC's A-plane and Rover programs, supported the view that the atomic-rocket program can go faster. "We feel we can develop and demonstrate a Rover rocket device more quickly than the requirements stated to us so far," he told the House space committee. Even more optimistic was his deputy, Col. Jack Armstrong, who declared that the U.S. could have an all-nuclear three-stage rocket which could land and return a manned expedition to the moon by 1970. Despite confidence in nuclear systems, however, neither official was willing to recommend that NASA hold off on its colossal Nova vehicle. "The decision on nuclear vs. chemical rockets is at least 10 years away," Col. Armstrong said.

• "AEC wants us to specify missions and vehicles and timetables for the nuclear rocket," replied a NASA official, "but we don't think that is necessary until we know a lot more about the weight and power of the reactor. We've told them we want them to move as fast as they can to demonstrate the feasibility of the reactor in the breadboard configuration, and we'll take it from there."

• NASA envisages an initial Rover flight-test article of about 200 to 1000 megawatts (10,000 to 50,000 lb thrust) which could be placed in orbit aboard the Saturn and then fired up for lunar and interplanetary missions. The initial Rover, as a matter of fact, will only operate from orbit. It could not take off from the earth because of its low specific power—only 10–20 percent of its weight. Though less spectacular than Col. Armstrong's all-up nuclear rocket, NASA believes an orbit-starting engine is developable during the 1960's, while Armstrong's rocket probably is not.

• Krafft Ehricke of Convair, one of the most ardent nuclear rocket enthusiasts, urged that the U.S. "examine very closely progress in the nuclear field before a basic decision to go ahead with the Nova chemical rocket." Ehricke notes that the C-3 version of Saturn will be getting rather close to the ultimate in chemical rockets, whereas a nuclear rocket would represent a quantum jump ahead. He has described his own version of a nuclear rocket, called "Helios," which would stand 200 ft high and 32 ft in diam, have a gross weight of 1.8 million lb, and a first-stage thrust of 2.4 million lb from four chemical engines. These would be jettisoned at 200,000 ft, and the nuclear rocket would fire up with a thrust of 720,000 lb.

AUXILIARY POWER

• Three new auxiliary power devices for space vehicles have been unveiled by NASA and the AEC. NASA's entry is a 3-kw solar power system called Sunflower I. It will utilize a collector 34 ft in diam to focus sunlight on a boiler in which liquid metal will be vaporized and used to drive a turbogenerator. The system will include a sun seeker and an inertia-wheel attitude control system to hold it focused closely upon the sun and a heat storage unit so that it can continue to produce power while on the dark side of its orbit.

• The AEC's two units are both reactor-powered. One is Snap-8, which will generate 30 kw of electrical energy by means of a turbogenerator. Generally similar to the 3-kw Snap-2, the new unit is the first system deemed capable of supplying useful power for electrical propulsion systems in space. The other unit is Snap-10, which will employ a reactor with a cylindrical core measuring 5 x 8 in. It will produce 300 watts of electricity by means of thermoelectric conversion elements. Though the latter will have a much lower power-to-weight ratio than the Snap systems using turbogenerators, its life will be much greater because of its lack of moving parts.

MYSTERY SATELLITE

• Pentagon wags had a field day when the Navy passed the word that its radar fence had spotted a "dark" satellite in a near-polar orbit. ARPA promptly dubbed the stranger Unk I (for Unknown One). The Navy at first insisted it was a piece of Discoverer VIII, but the AF said it was more likely a secret Russian satellite. Still another faction said it was more likely an earth probe sent by the Martians to look us over.

• After the tumult faded, the Navy found that it had a trace of the stranger all the way back to Aug. 15, 1959, two days after Discoverer V was placed in orbit. It appeared virtually certain that the object was the capsule of that satellite, although it was originally believed the capsule had never been ejected because of battery trouble. If the object is Discoverer V's capsule, there's also a chance it might eventually re-enter as planned, once it descends into the atmosphere and the inertia switch, which deploys its parachute, is activated. Since it could come down anywhere, the AF is having some sleepless nights. That Discoverer V capsule wasn't empty by any means, and the airmen would hate to see it fall in Russia.

SPACE TECHNOLOGY

• NASA expects to orbit two Tiros meteorological satellites this year, followed by the Nimbus by 1962. Tiros I, scheduled for launching in March, will be a 270-lb spin-stabilized package measuring 42 in. in diam and 19 in. high. It will be equipped with television-scanning and magnetic-memory devices. Tiros II will be similar, except that it will also have infrared scanning equipment to gather important information on the earth's heat balance. Both are to be placed in a circular orbit at 380 n.mi. altitude, with an inclination of about 50 deg.

• The follow-on Nimbus meteorological satellite will be a 650-lb package placed in a polar orbit by a Thor-Agena B. It will be stabilized by an inertia-wheel technique with an accuracy of about 1 deg, and it will be solar powered. In addition to TV and infrared sensing devices, it will also incorporate radar to provide information on rain and snow areas and the altitudes of their layers.

• NASA has computed that a total of 26 aluminized spheres would have to be placed in orbits of 3000–4000 miles' altitude to provide 99 percent availability for communications relay. In view of this requirement and the advent of larger boosters, the space agency is considering a follow-on program to Project Echo which would develop the ability to put a number of spheres in orbit with a single vehicle.

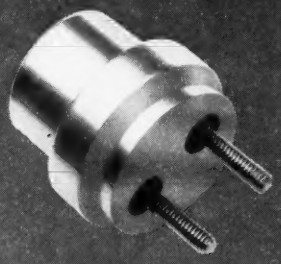
• NASA's first lunar impact shot is planned for next fiscal year with

Mc/S/A EXPLOSIVE ORDNANCE

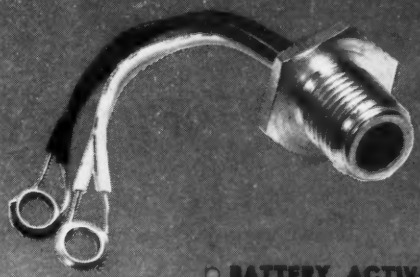
IN STEP WITH THE FUTURE

The powerful ATLAS intercontinental ballistic missile, built for the United States Air Force by Convair-Astronautics, has proven its reliability as a military weapon system. In addition, it will earn its keep by itself into interplanetary space in search of scientific knowledge of our solar system and its environment.

McCormick Selph Associates explosive ordnance devices play a major role in the ATLAS system — M-92 pressure cartridges actuate the twin-chambered booster engine separation system, and battery activation cartridges allow power to be generated for operation of systems within the missile nose cone.



○ M-92 PRESSURE CARTRIDGES



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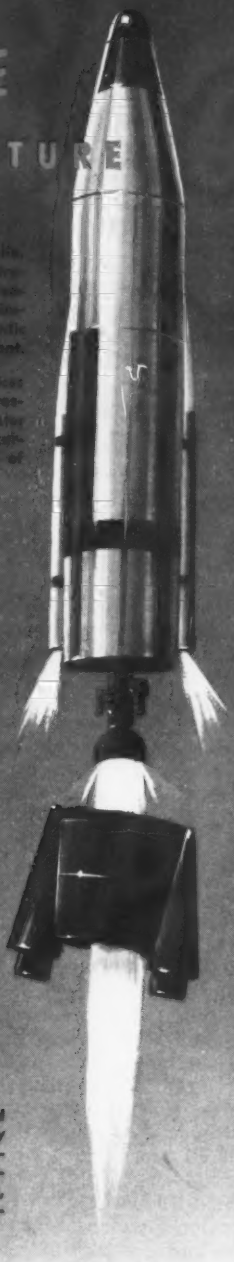

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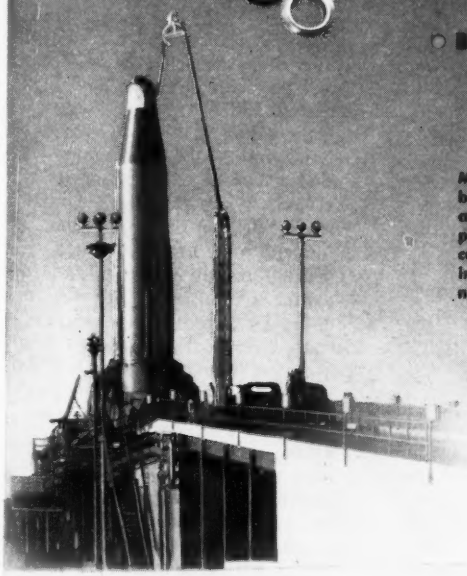

*Nose cone supplied by General Electric, Missile and Space Division

EXPLOSIVE ORDNANCE

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Physical Chemists, Engineering Physicists and Chemical Engineers are invited to submit resumes to Frank LaHaye, Vice President, Engineering for position openings in all phases of explosive ordnance.

the Atlas-Agena B. This will be a 700-lb vehicle equipped with television cameras to obtain and to relay close-up pictures of the moon's surface. It will also contain attitude control and navigation equipment so that at the proper moment it can detach a part of itself, which will then be slowed by retrorocket and land on the moon, with penetration spikes absorbing the remaining energy. The mother vehicle, of course, would be destroyed by the lunar impact.

• It never fails. NASA wiped out its Vega program in December, banking on the expected high degree of reliability which the AF had achieved with the Agena second stage. The AF immediately found itself jinxed with Agena. Discoverers IX and X failed to make orbit, as did the first Midas infrared warning satellite which was launched from Cape Canaveral.

• NASA scheduled a 23-lb radiation-detection satellite for a launching in March aboard a Juno II. Designed by James Van Allen, the package was to be projected into a high-apogee (25,000 miles) orbit similar to that of Explorer VI. Equipped with solar cells, the satellite, Dr. Van Allen believes, will be fortunate to operate for as much as two months, because of damage which the energetic electrons in the outer radiation zone will do to the semiconductor materials of the cells.

• Princeton's Lyman Spitzer proposed an interesting concept for a 24-in. satellite telescope in the March issue of *Sky and Telescope*. The observatory would be devoted to ultraviolet spectroscopy in the range of 800 to 3200 Å, with the hot star, Zeta Persei, one of the first targets. Dr. Spitzer proposes a novel technique for controlling the attitude of the one-ton observatory to 0.1 sec of arc: An aluminum shell, suspended in a variable magnetic field, which can be made to spin in any direction to compensate for torque in the observatory.

• The first Scout satellite will incorporate a micrometeorite experiment to gather information on the "puncturability" of small meteorites. The payload will consist of a number of short metal tubes of various thicknesses which will contain gas under pressure. When a tube is punctured, the loss of pressure will be registered and telemetered to ground stations.

• NASA is studying an interesting technique for hard lunar landings of small instrumented packages: A so-called gas cushion in the middle of which the instrument package suspends by radial cords. Upon impact, the cushion compresses and the instrument package comes to rest. The cushion is split at this instant to avoid rebound. A major advantage of the gas bag technique is the fact that it will require no stabilization or orientation. Sizes might range from 5 to 25 ft depending upon system weight.

• NASA and GE tested a nuclear-emulsion recovery payload (NERV) early in March by dropping it into the sea from an aircraft at an altitude of 7 miles. The package came through the drop and recovery without being affected by impact or the dunk in sea water. The drop test was part of a NASA program leading to launching such packages to study the Great Radiation Belt.

• Republic Aviation reports that its magnetic-pinch nitrogen-plasma engine has been run continuously for more than 118 hr, cycling at a rate of 30 times per min on 3000-v, 675-w power. As a result of this performance, Republic plans to design immediately a "flyable" plasma engine. Such engines have a variety of possible satellite applications.

• J. Allen Rynek, associate director of the Smithsonian Astrophysical Observatory, comments on proposals to use flashing lights on satellites for optical tracking. According to Dr. Hynek, "These suggestions, insofar as they concern positional accuracy, overlook salient astrometric facts relating to atmospheric unsteadiness and image motion, which can cause the instantaneous photographic position of the satellite image to differ from a true position by easily as much as two or three seconds of arc."

SATURN TESTING

• NASA expects to flight-test its first million-pound-thrust Saturn in September 1961, and to have an operational three-stage Saturn by mid-1964, according to Brig. Gen. Don Ostrander, director of Launch Vehicles. He told a House space subcommittee that the first three Saturns will have dummy upper stages, the next three will have live first and second stages and dummy third stages, and the last three will have all active stages. The 10th Saturn would be declared operational. Under the expedited program, he said, the first Saturn launching will take place in 1961 instead of 1962, three instead of two Saturns will be launched in calendar 1962, five instead of three in 1963, and six instead of four in 1964.

• To insure the time won by the acceleration, Gen. Ostrander asked for funds to build a second static-testing stand for the Saturn eight-engine cluster at Huntsville and a second launching pad at Cape Canaveral. He warned that a catastrophic failure of Saturn on either facility could retard the program by as much as 9 months unless there is a spare facility.

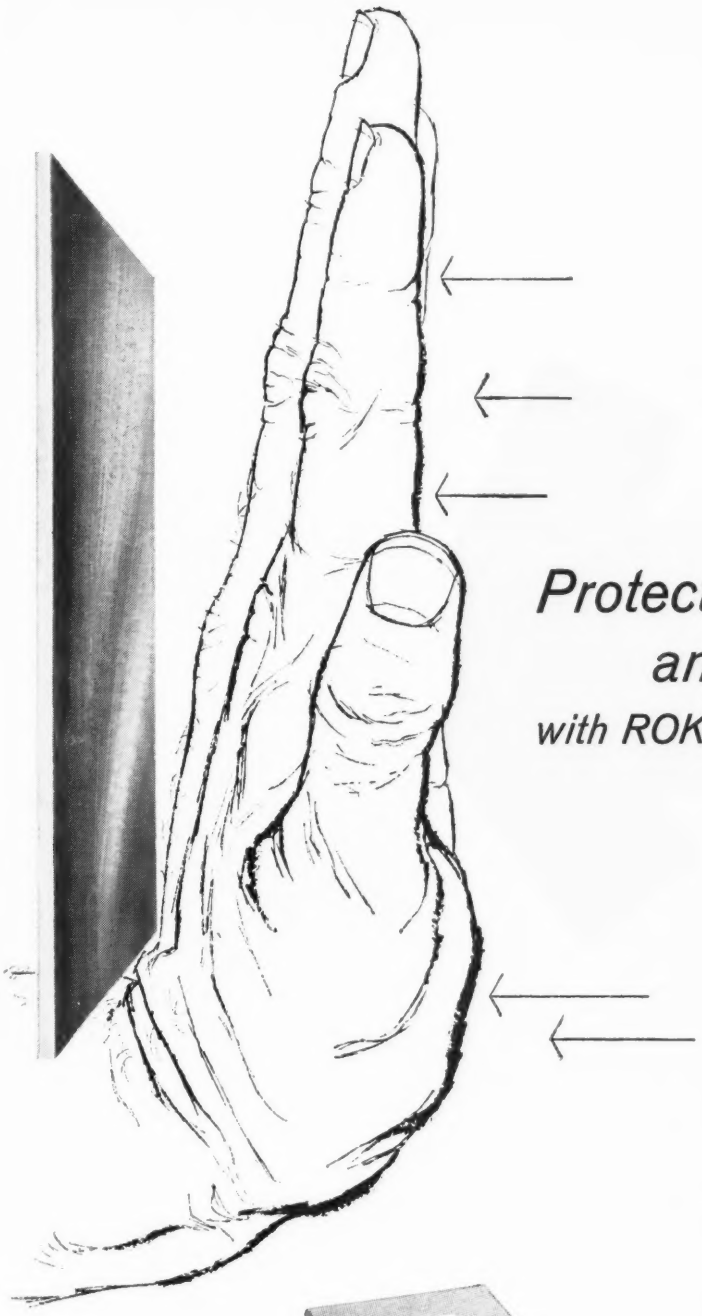
SPACE SCIENCE

• John Strong of Johns Hopkins Univ. has found more water vapor above the cloud layer of Venus than there is in the earth's own stratosphere. Dr. Strong and his colleagues estimated there is 15 to 30 microns of water vapor in the vertical regions above the clouds of Venus, compared with about 6 microns in the earth's stratosphere on a quiet day. The findings were based on infrared spectroscopic data obtained by Charles Moore and Comdr. Malcolm Ross in a balloon flight to 80,000 ft last November.

• After two years of watching their colleagues in the physical disciplines monopolize satellite payloads, the life scientists are at last going to get a chance to conduct space experiments on a large scale. Following recommendations of the Bioscience Advisory Committee, NASA created a new Office of Life Sciences at the top of its administrative echelon—on a par with Silverstein's space flight programs, Abbott's advanced research programs, and Ostrander's launch vehicles—and named as director Clark Randt, a 43-year-old neurologist. The new office will establish its own in-house capability to provide leadership for the program, although it will continue to rely mainly upon military facilities. As a first step in organizing his program, Dr. Randt expects to hold a conference to discuss objectives, appropriate experiments, and priorities. He hopes to have a biological payload in orbit next year.

• Originals of Soviet photos of the back side of the moon, now under careful study by U.S. photographic experts, indicate there was some retouching but not enough to make the photos "immoral." One expert noted that his study of the photos leads him to believe the Russians

(CONTINUED ON PAGE 11)



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ROKIDE Coatings are extensively used for both military and industrial applications such as: missile components, bearing surfaces, extrusion dies, furnace and feed rolls, induction coils, igniter tips, strain gages, buffing fixtures, mechanical seal rings, pump shafts, capstan wheels, impellers, crucibles, etc.

ROKIDE Coatings are available from a number of strategically located job shop applicators or direct from Norton Company, Worcester, Mass., and Santa Clara, California. Find out how they can cut *your* maintenance and production costs. NORTON COMPANY, 643 New Bond Street, Worcester 6, Massachusetts.

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– developed and produced by Martin

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may have even better shots which have not as yet been released.

PACIFIC MISSILE RANGE

• DOD officials are hopeful that the friction between Vandenberg AFB and the Navy-operated Pacific Missile Range has been largely eliminated through a new agreement relating to AF research and development launchings at Vandenberg. The Navy had objected strenuously when the AF commenced firing Discoverers with its own destruct systems aboard. The AF argued that it was following the pattern of its ballistic-missile training shots from Vandenberg; but it abandoned this position in the Burke-LeMay agreement reached last fall. Now PMR controls all R&D shots just as the Atlantic Missile Range does.

• NASA's equatorial launching site committee, headed by John Hagen, has completed its study and delivered it to NASA Director Keith Glennan. Its recommendations have not been revealed, but it's understood the group sees no clear-cut requirement for such a site. The Navy, which would have such a site established as part of PMR, has argued that an easterly launching along the equator would sharply boost payloads and ease the rendezvous problem. But the chief obstacle is cost. Unless NASA decides in favor of an equatorial site, there is little prospect the U.S. will build one because there is no military requirement for it.

MISSILES

• The question of the number of ballistic missiles to be emplaced by the end of 1962 has received further consideration by the Administration, and according to Secretary of Defense Thomas S. Gates Jr. the door has been left open to increases in the number of Atlas missiles and Polaris submarines presently scheduled for this period. Thus DOD has modified its position on these missiles slightly in face of widespread criticism of the nation's defenses during the next two years. The AF proposes adding several more missiles to each of its planned squadrons. The Navy would like to start work on six additional Polaris submarines.

• The Navy is seeking funds for development of two novel space systems in fiscal 1961. One, designated Project Yo-Yo, would be an airlaunched tactical reconnaissance satelloid which would make a single pass around the globe to gather information. The other, an antisatellite weapon, would be a sort of space "depth charge," which would strew sand or shot in the path of an enemy satellite to put it out of commission. The latter would be launched by a shipboard rocket using rendezvous information provided by the Navy's Space Surveillance (Spasur) network.

• For its 100-mile Eagle air-to-air missile, the Navy is seeking a carrier-based launching plane using turbofan engines which will have a 4-hr cruising capability while flying aid cover. The plane would have to accommodate six missiles, and would need a 5-ft radome to detect and identify targets and direct the missiles. A half-dozen companies have submitted technical proposals on the aircraft, which is designated "Missileer."

• Typhon is the Navy's concept of the next-generation surface-to-air missile defense for the fleet. The Typhon system, reportedly a combination of "Super-Talos" and "Super-Tartar," would have a detection range of 200 miles and an intercept range of 100 miles. The sailors argue that Typhon complements Eagle, both being needed for effective fleet air defense.

• The Army has asked Congress for some $1.4 million to purchase 1700 Redeye missiles, which are made by Convair-Pomona.

• The U.S. will outfit Canada with two Bomarc bases free of charge except for basic site preparation. The Bomarc investment, amounting to $72 million, will make it unnecessary for Canada to continue with its plans for the Arrow jet interceptor, which would have been financed in the amount of $342 million in the coming fiscal year.

• On the last day in February, the Douglas Thor proof-testing program saw its last firing from Cape Canaveral. Forty-five missiles were launched in the program.

• BMD accepted the first Burroughs IOC guidance computer for Atlas, and turned it over to SAC at Vandenberg AFB. This model of the computer can be operated by one man, according to Burroughs.

• The Marine Corps activates its first Hawk battalion May 2 at Twentynine Palms, Calif. The Raytheon-developed missile will replace conventional antiaircraft guns. The entire new battalion can be transported by helicopter.

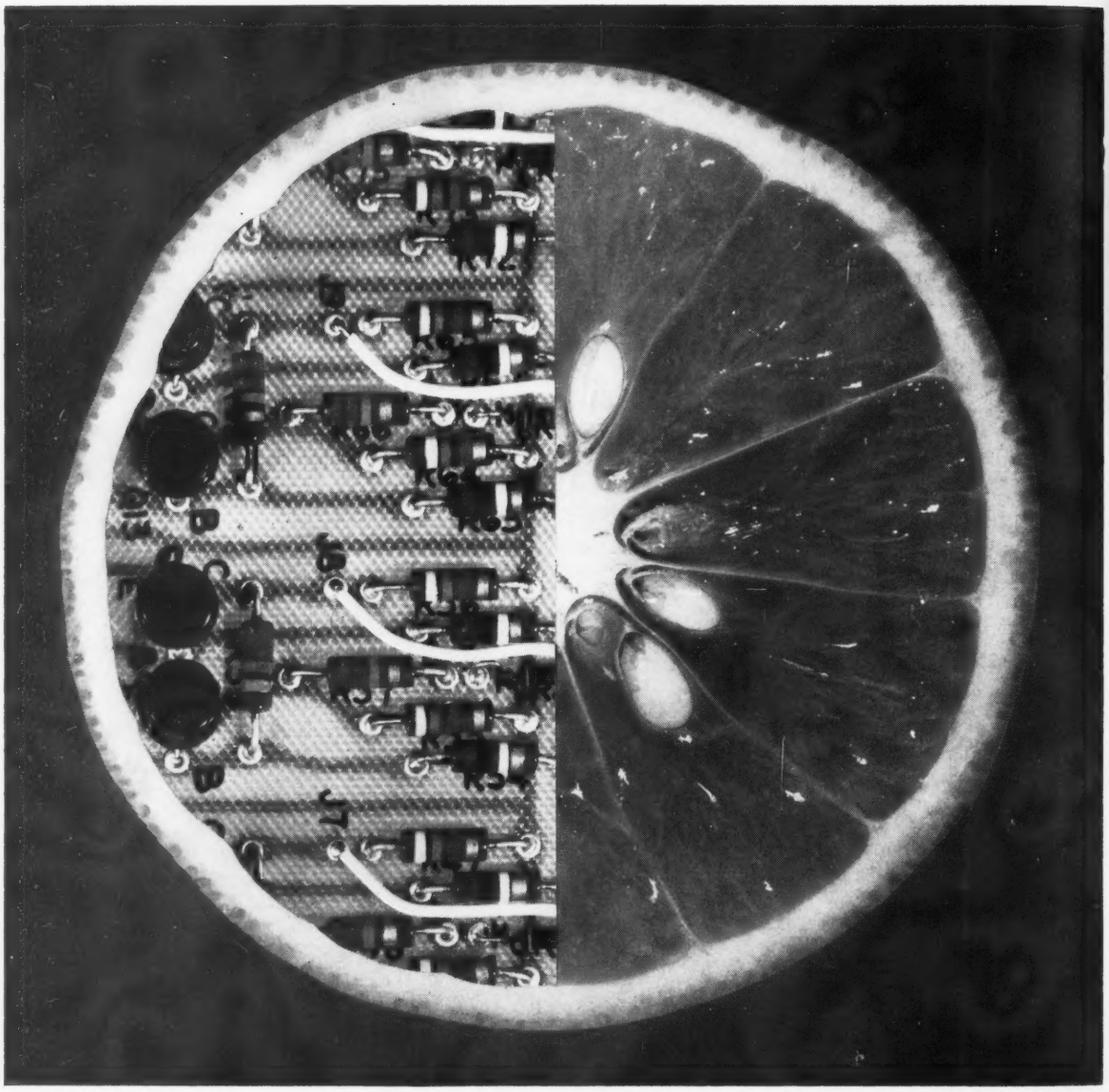
• GE's pioneer heat-sink re-entry vehicle, the Mark II, which became the nation's first operational nose cone, saw its last scheduled flight from Cape Canaveral. The Mark III being developed by the Missile and Space Vehicle Dept. has an ablation heat shield.

• The AF retrieved a data package from the 5000-mile Titan flight late in February. Developed by Avco's Research and Advanced Development Div., the capsule successfully recorded flight data during the crucial blackout period of re-entry.

• Recent flight-tests of major missiles have for the most part been very successful. Early in March, several days after one Atlas blew up, while sitting on a pad at Cape Canaveral before a countdown, the AF successfully launched the first big bird to carry the American Bosch Arma all-inertial guidance system. The inertial system ran on an "open loop," that is, functioned but did not generate steering commands. Its response was compared with the GE-Burroughs ground-command system, which directed the flight . . . About the same time, Polaris zipped over a 900-mile trajectory in a test of advanced flight-control equipment. The previous Polaris fired late in February went out of control and was destructed, ending a string of six successful flight-tests . . . The Army fired the fifth flight-test model of Nike-Zeus March 9. The missile performed well at hypersonic speeds . . . As of March 5, seven Bomarc-B's had failed in a row in launchings at Canaveral.

• Boeing disclosed that it has received $1.6 million funding for work on the solid-propellant air-launched ballistics missile Skybolt being developed for the AF under a weapon-system-manager contract by Douglas. The Wichita Div. is doing Boeing's work.

• The day of the hardened-site, underground missile may be over before it begins if missile accuracy continues to improve at the current rate. According to Lt. Gen. Bernard Schriever, commander of ARDC, when ICBM accuracy gets down to 1 mile, the 100-psi-protected missile will be "pretty much finished," because an enemy will no longer need to build 5 or 10 attack missiles of his own to knock out one of ours—a much smaller number will suffice. Gen Schriever does not believe Russia has attained 1-mile accuracy, but he sees no technical obstacles to its attainment by either the U.S. or Russia.



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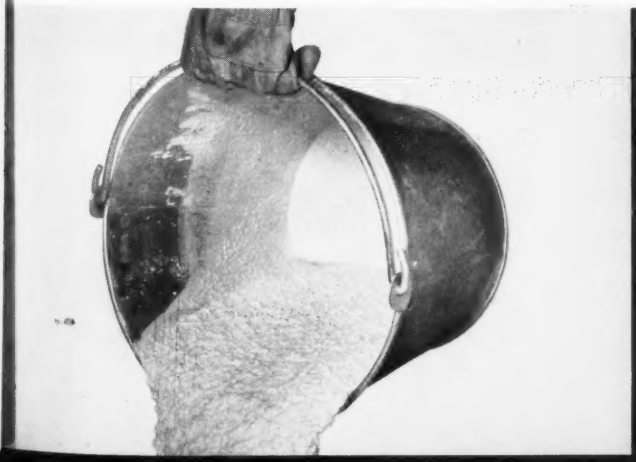


Marquardt ADVANCED PRODUCTION CAPABILITY for air and space

MARQUARDT/OGDEN RAMJETS FOR USAF-BOMARC PROVE 100% RELIABLE

Marquardt/Ogden delivered its first production engine to the Air Force in June 1957, one month ahead of schedule. This was achieved despite the problems of creating, building and implementing a modern production facility and staffing it with qualified engineers and technical personnel. In the more than two years since, each and every delivery has been as-per-contract-schedule, while Ogden ramjets have proved 100% reliable in all test flights of Bomarc IM-99A.

By strict adherence to a realistic learning curve, Ogden Division currently delivers its supersonic ramjets at far less than their mid-1957 delivered cost—this despite the ramjet engine system's relatively early stage of maturity.

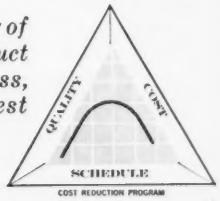
Recent expansion and additions further enhance Marquardt/Ogden's capability. In 1958 the plant doubled floor space to almost ¼ million square feet, with numbers of employees increasing 93%. 1959 marked Ogden Division's addition of a first-of-its-kind Spin Forge and completion of a new facility for explosive metal forming. Ogden's USAF-Marquardt acceptance test facility at Little Mountain gives the Division full-plant capability.

Marquardt/Ogden is now capable of producing space-age hardware in all of its basic configurations—cones, cylinders, rings, parabolic shapes—using the most sophisticated of space-age metals.

Responsible for Marquardt/Ogden's record are: a creatively cost-conscious management team headed by Mr. D. K. Tasker (pictured left); early application of industry's newest and most advanced production and metal working techniques; a facility cited by *Factory Magazine* as one of America's top ten; and the efforts of the Division's nearly 2,000 men and women workers. All combine to provide Department of Defense and Weapon Systems Managers with a unique capability for the on-time delivery of reliable space-age hardware at minimum cost.

For additional production capability specifics, you are invited to contact: Manager, Customer Relations Department, Ogden Division, The Marquardt Corporation, 1000 West 33rd Street, Ogden, Utah.

Current expansion creates a number of outstanding opportunities for: Product Development, Materials and Process, Manufacturing and Production Test Engineers; and skilled machinists.



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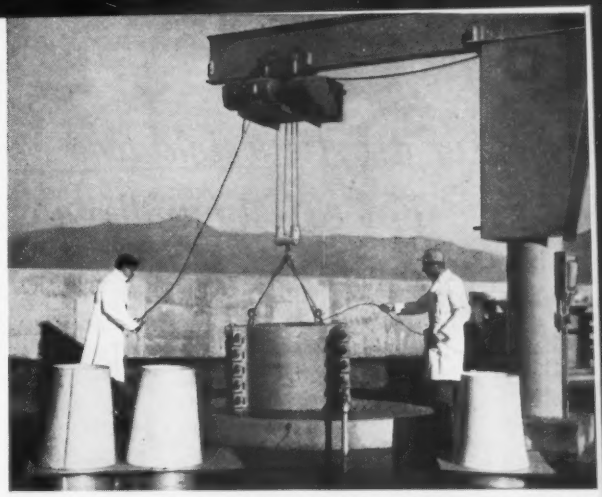

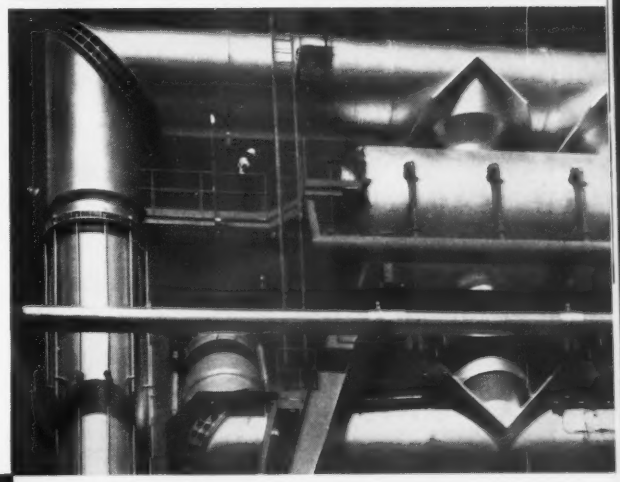

TOP High energy (explosive) forming produces heretofore "impossible to form" shapes—typifies Marquardt/Ogden's continuing quest for optimum materials and processes which advance the art of metal fabrication.

CENTER Marquardt/Ogden's massive Spin Forge is the most powerful of its type for cold-flow forming of space-age metals. It compliments the Division's new explosive metal forming facility and other specialized equipment.

BOTTOM USAF-Marquardt Jet Laboratory-Ogden at Little Mountain, some 15 miles West of Ogden, acceptance-tests every production engine system produced by the Division; is capable of simulating flight at speeds in excess of Mach 3, altitudes above 100,000 feet.

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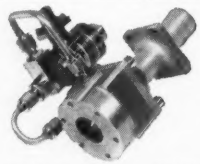
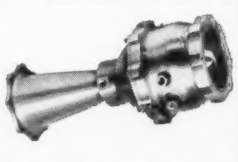
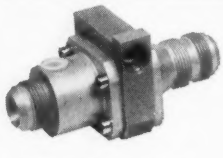


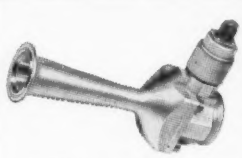
X-15 Hydrogen Peroxide Valve



4" Decaborane Shut-off Valve



Cryogenic Relief Valve



Cavitating Venturi Shut-off Valve

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International scene

By Andrew G. Haley

THE SCIENTIFIC community south of the border is making real progress in astronautics. A Mexican Astronautical Society has been formed under the patronage of Walter C. Buchanan and J. Manuel Ramirez Caraza, secretary and undersecretary, respectively, of the Mexican Dept. of Communications. Much of the "spadework" has been done by Carlos J. Nunez, who is chief of the Office of International Relations of the department, and Antonio Francoz. The Society has approximately 100 members, many recruited from the faculty and graduate school of the Univ. of Mexico. Material is on hand for the first issue of a quarterly journal and publication will be undertaken immediately.

° ° °

The committee for the organization of the IAF Institute of Space Law met in Paris in March to consider adoption of its own statutes and review the proposed new IAF Constitution, as well as the statutes of the International Academy of Astronautics. This committee consists of Christopher Shawcross, Q.C., (UK); Michel Smirnoff (Yugoslavia); Robert Homburg (France); Fritz Gerlach (German Federal Republic); John Cobb Cooper (U.S.A.); and Andrew G. Haley (U.S.A.). Well before the 11th annual IAF Congress in Stockholm in August, reports will be submitted to the member societies and to the IAF Presidium.

° ° °

The seven-day International Symposium on Rockets and Astronautics, sponsored by the Japanese Rocket Society in May, will be most comprehensive and will cover propellants, propulsion systems, vehicles (aerodynamics, structures, astrodynamics, etc.), instrumentation (telemetry, guidance, tracking, instruments, etc.), space science (space physics, space communications, etc.), space biology, and space law.

The Japanese Rocket Society now has more than 300 members. Officers are: Naonobu Shimomura, chief engineer, Communication Service Div., Tokyo Shibaura Electric Co., (president); Seiichiro Nozawa (executive secretary); and Kiro Honjo, counsellor, Mitsubishi Heavy-Industries, and Ikio Takashiba, director, Technical Develop. Div., Kawasaki Aircraft Co., (treasurers).

Current JRS activities include not only the Symposium but lecture series, the publication of monthly and quarterly journals, semiannual astronautics exhibitions, and participation in actual experimentation, such as development of the Rockoon system.

° ° °

John Cobb Cooper, general counsel of the International Air Transport Assn. and founder of the Institute of Air Law of McGill Univ., has taken time out of his worldwide travels to briefly summarize the main problems of air law and space law, as follows:

(1) The air-space over a sovereign State is part of the territory of that state.

(2) Such State has the sole right to control all flight in such air-space above its lands and waters, and the unauthorized entry of any foreign flight instrumentality is a violation of State sovereignty.

(3) "Air-space" extends upward through the areas where "aircraft" may be operated which depend solely on the gaseous air for aerodynamic lift to maintain flight.

(4) "Air-space" may possibly be construed to extend further upward to include all areas where the atmosphere is sufficiently dense to contribute in any degree to aerodynamic lift or even higher to include all areas where the atmosphere is sufficiently dense to prevent a satellite's orbit.

(5) No general rule of customary international law exists as to the subjacent State's rights to control all flight in areas above the air-space, nor whether on the contrary such area should be treated as free for international flight as the high seas are for shipping, although strong arguments can be made that this should be future law.

(6) Each State, however, probably has a present right under international law to act in outer space above it to the extent necessary for its self-protection or self-defense, even if such areas are beyond its territorial space.

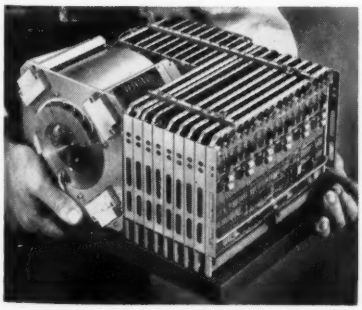
(7) Flight over stateless lands, such as Antarctica, is free at all heights and subject to no control except that of the State which launches or operates the instrumentality.

(8) Flight over the high seas is free at all heights, subject only to paragraph (6) above and the "rules of the air" adopted by the International Civil Aviation Organization under Article 12 of the Chicago Convention. The power of ICAO to adopt such rules should be deemed limited to flight in the air-space and not to outer space beyond.

(9) Article 3 of the Chicago Convention prohibiting flight of State aircraft over the territory of another State, and Article 8 prohibiting the flight of pilotless aircraft, in each case without special authorization, should be construed as applicable in the air-space only, even if the annexes to the Chicago Convention are amended to widen the present definition of aircraft so that it will no longer include only "machines which can derive support in the atmosphere from reactions of the air."

(10) Chaos in future high-altitude flight can be avoided only by international agreement, applicable either (a) through regulation of individual flights, or (b) through a determination of the boundary between air-space and outer space, and some understanding of international control in outer space. ♦♦

Digital Computer for Centaur



Developed by Librascope for Minneapolis-Honeywell, this miniaturized digital computer will be integrated with the Centaur guidance system, accepting and processing inputs from the inertial platform and feeding out steering signals to the space vehicle's control system. Based on silicon transistors, the computer weighs 32 lb and takes up only 0.55 cu ft.

Data on R&D

The latest report in the National Science Foundation series, "Reviews of Data on Research and Development," is on research and development expenditures of selected groups of nonprofit institutions during 1957 (No. 18, 5 cents, from the GPO).

For the record

The month's news in review

Feb. 1—President Eisenhower announces he will ask $113 million more to speed development of superthrust boosters for our space program. Of this sum, NASA says it has earmarked $90 million for Saturn boosters; $15 million for Nova rocket engine; and $8 million for Saturn upper-stage liquid hydrogen engines. This brings to $915 million the total NASA is seeking for fiscal 1961.

—Maj. Gen. August Schomburg takes over as commander, AOMC, succeeding Maj. Gen. John B. Medaris.

—Navy-NSF Skyhook balloon rises to 21.4 miles.

Feb. 2—Titan second stage separates successfully under command guidance in 2000-mile AF flight-test.

—Administration ups Saturn funds from $140 million to $230 million for fiscal 1961.

Feb. 4—Stanford Univ. scientists report bouncing radar signals off sun's corona last April.

—Aerojet scale model of "building block" solid-fuel rocket engine demonstrates 40,000-lb thrust.

—Discoverer IX fails to achieve orbit.

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Feb. 5—Titan explodes seconds after liftoff.

Feb. 7—New Explorer VII data show that outer Van Allen belt's rim moves north and south as much as 500 miles in latitude, and varies in intensity tenfold within a few hours.

—Project Rover budgeted $39 million, 25 per cent less than requested.

Feb. 8—Navy says it will request $975 million supplementary budget for six more Polaris submarines.

—House approves transfer of ABMA team to NASA.

Feb. 9—AF dedicates National Space Surveillance Control Center at Bedford, Mass.

Feb. 10—DOD announces spotting mystery satellite in near polar orbit last January, believes it may be ejected Discoverer V recovery capsule launched August 1959.

Feb. 11—X-15 ascends 15 miles in powered flight.

—Army discloses "first known kill of a ballistic missile" by an AA missile, with Hawk downing an Honest John on January 25th.

—AF sends Mace-B on unusual curved flight.

—M. Karimov, director of the U.S.S.R. Khazakhstan Mountain Astro-Physical Institute, says Soviet scientists are on the track of a new small planet in constellation of Capricorn.

Feb. 17—X-15, put through power dive, hits 1400 mph.

—U.S. and U.K. agree to set up radar base in Yorkshire for early warning of missile attacks on North America.

Feb. 18—President nominates Courtland D. Perkins of Princeton Univ. as Assistant Secretary of the Air Force.

Feb. 19—AF destructs Discoverer X.

—AF fires three-stage Exos composite rocket.

—NASA announces plans for Venus probe during March.

Feb. 23—House approves $23 million more for man-in-space program and revamp of launching pads at Cape Canaveral.

Feb. 24—AF Titan covers full 5000-mile range, ejects data capsule in "highly successful" test.

Feb. 25—Army's first Pershing test-flight is success.

—U.S. and Australia agree to space exploration exchange.

Feb. 26—AF's attempt to orbit Midas fails; Navy destructs Polaris.

Feb. 27—AF does turnabout, orders its commands to treat sightings of UFO's as "serious business."

Feb. 28—AF decides to develop high-thrust rocket using solid fuels in test of President's order giving NASA "sole responsibility" in this field.

Feb. 29—Cape Canaveral ends Thor tests. ♦♦

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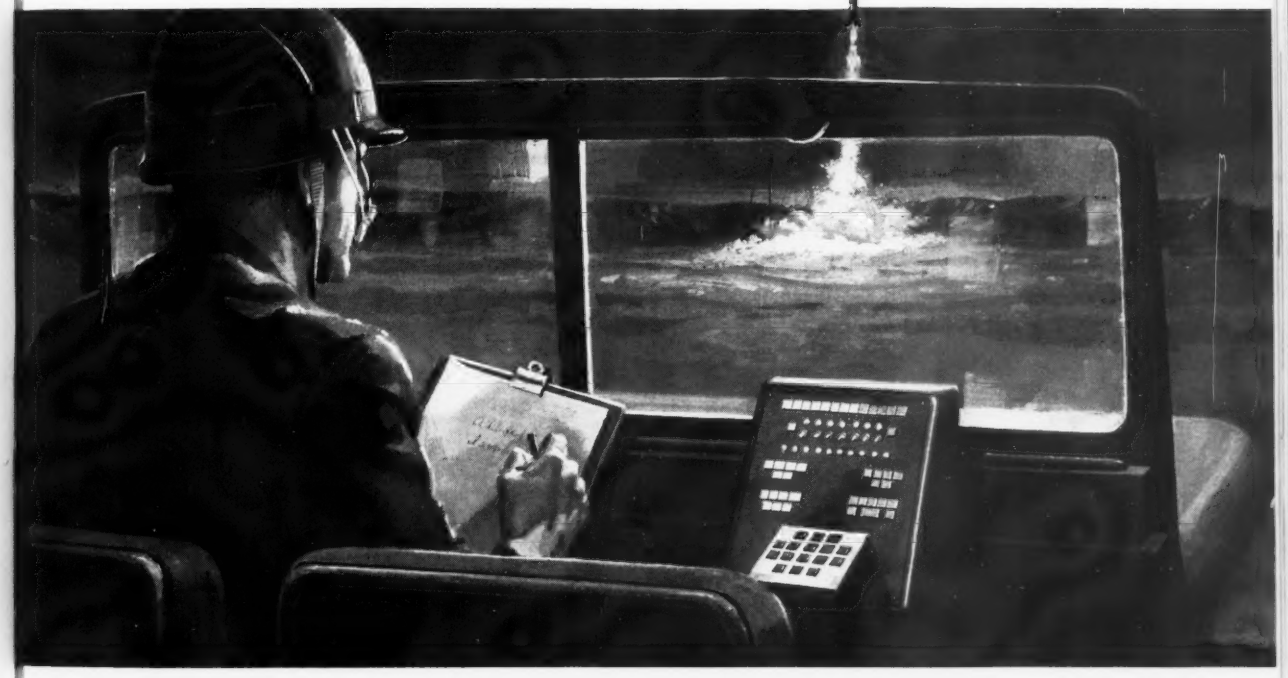
EQUIPMENT



The micro-module is a new dimension in military electronics. It offers answers to the urgent and growing need for equipment which is smaller, lighter, more reliable and easier to maintain. Large scale automatic assembly will bring down the high cost of complex, military electronic equipment. Looking into the immediate future, we see a tactical digital computer occupying a space of less than two cubic feet. It will be capable of translating range, wind velocity, target position, barometric pressure, and other data into information for surface to surface missile firings. The soldier-technician monitoring the exchange of computer data will have modularized communications with the other elements of his tactical organization. RCA is the leader contractor of this important United States Army Signal Corps program and is working in close harmony with the electronic components industry.

RCA Tmk(s)

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

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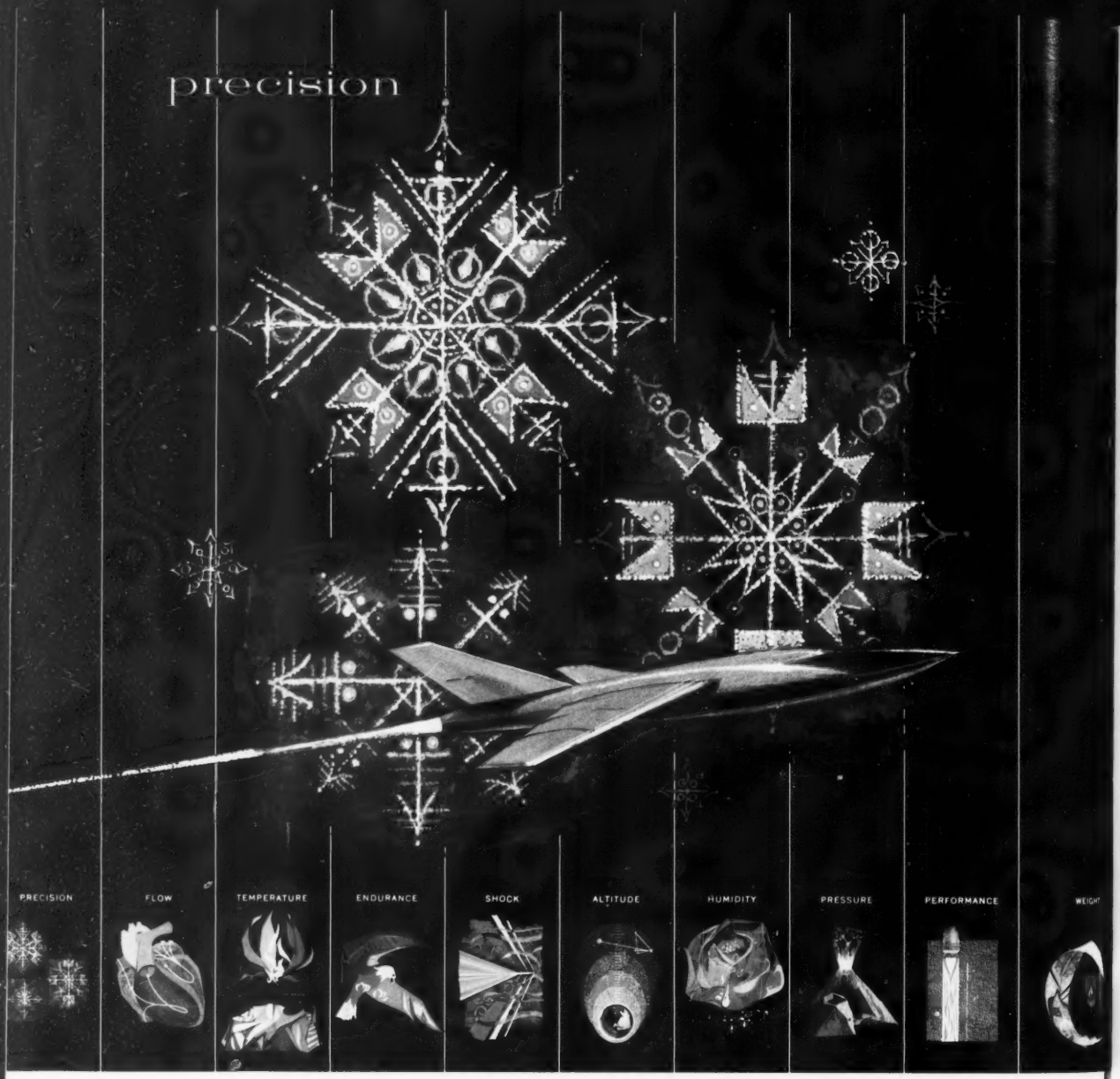
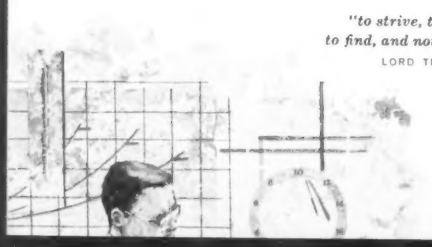


NEW DIMENSIONS IN

reliability

"to strive, to seek, to find, and not to yield"
LORD TENNYSON



reliability

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COVER: *"Luna," another photogram by Erich Locker and Gladys Washburn, provides an exciting impression of the target for a good many space missions in the next decade. Moon photo is from Lick Observatory. (Full-cover ASTRO cover plaques, 11 x 12 in., are available from ARS headquarters at $2 each.)*

Astronautics

APRIL 1960

Science and Statesmanship

The House Committee on Science and Astronautics recently requested the ARS, through its President, to testify concerning the adequacy of the U.S. Space Program. It was my privilege to appear before the Committee on February 23 and summarize the views of our Board of Directors, who had given 100 percent response to a telegram of inquiry. Here is a condensation of the prepared statement:

Planning: Since oscillations of opinion are technologically damaging, a clearly defined and stable U.S. policy is needed. It should recognize the importance of the cold-war space race for spectacular scientific achievement, and implement NASA accordingly. Clarity of long-range goals and steadiness and firmness of purpose are essential. Another administrative reorganization now is neither necessary nor desirable.

Funding: Funds should be allocated for five years or longer, rather than yearly. This would give continuity to the efforts both of planners and doers. Long-term money is particularly needed for basic research, which is an inherently long-range activity. Budgeting fluctuations wreck the effectiveness of research teams.

Technical Goals: Emphasis should be given to the long lead-time items such as million-pound class boosters and advanced propulsion concepts without which major exploratory work in deep space cannot be done. In addition, payload instrumentation should be developed energetically and concurrently so that it will be available when the boosters are ready. Careful balance between military and nonmilitary technical objectives is essential, lest the purely scientific goals be starved out in the competition for limited talent, funds, and facilities.

These hearings, which are a valuable part of the process of candid communication between technology and government, are attempting the complex job of interpreting engineering opinions to our legislators. Let us hope that we can mix science with statesmanship, and not be accused of merely combining propulsion and politics.

Howard S. Seifert
President, AMERICAN ROCKET SOCIETY

The plug nozzle: A new approach to engine design

Promising a shorter development cycle at substantial cost savings, such engines may also provide operation advantages of reduced size, the elimination of gimballing, and improved low-altitude performance

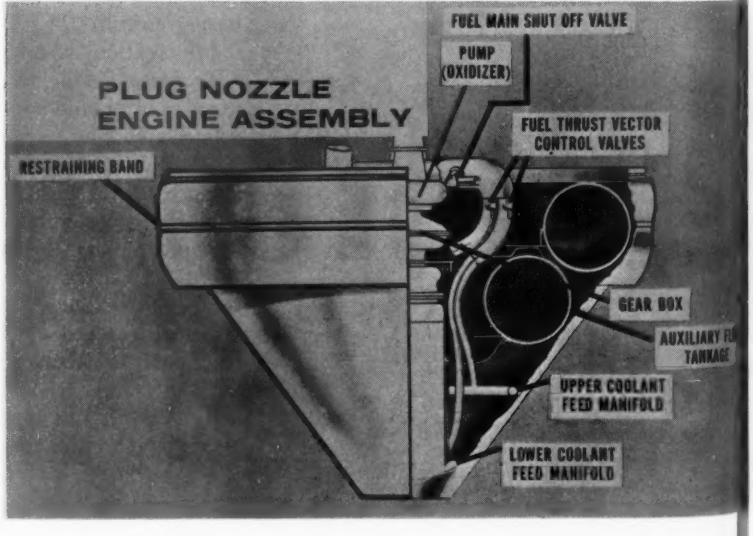
By Kurt Berman

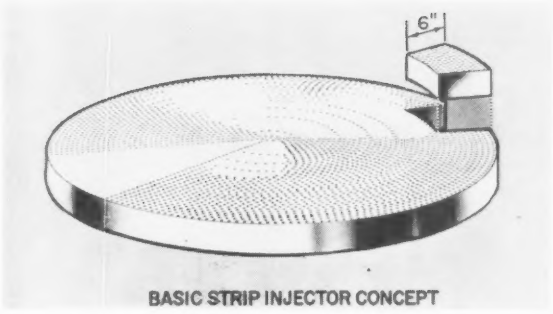
GENERAL ELECTRIC CO., CINCINNATI, OHIO

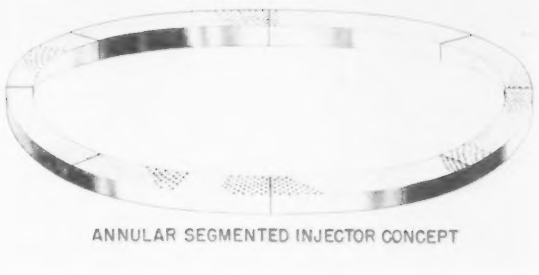
OUR NATION's ability to gain the initiative in space exploration depends to a large extent on having the required reliable propulsion systems available. Such systems should be "tailored" to the requirements of the contemplated space mission, rather than have mission capability compromised by available propulsion systems. To attain leadership in space exploration, it is necessary that reliable rocket-propulsion systems be developed much more rapidly and efficiently than has been done in the past. It is possible to speed up development somewhat by conducting it on a "crash" basis without regard to financial expenditure. However, this cannot be justified except in cases of extreme emergency. What is really required is a different technical approach which provides a shorter development period as its natural consequence.

Approximately six years ago, the General Electric Co. initiated an extensive company-funded study to explore ways of building large-thrust rocket engines. These investigations, now being supplemented by a study contract awarded by NASA, led to the pio-

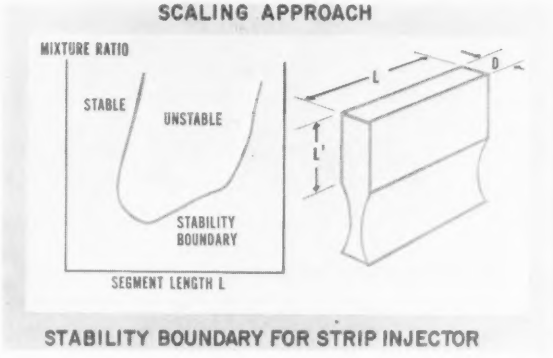
Kurt Berman, now manager of rocket motor engineering for GE's Flight Propulsion Laboratory Dept. at Cincinnati, received his B.S. in chemistry at Western Reserve Univ. in 1945 and his Ph.D. in applied physics in 1950 at Harvard. An ARS Fellow, Dr. Berman has devoted the past 12 years with GE to work in such areas as rocket-propulsion instability problems, development of new propellants and propellant combinations, and small particle and encapsulation development. An adjunct professor of aeronautical engineering at the Rensselaer Poly School of Engineering, he is the author of eight unclassified papers in his various areas of specialization.

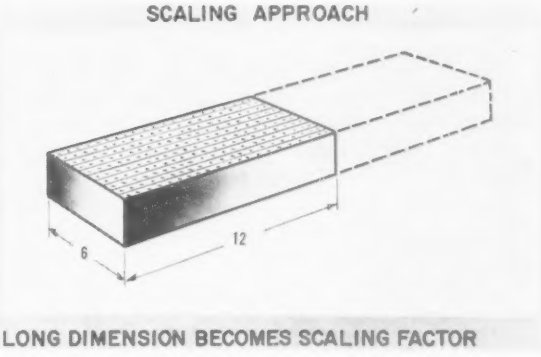






Basic strip injector concept (left) involves replacing the usual circular combustor with annular segmented combustor (right). Scaling approach used is shown below.





neering of a unique engine-design concept called the plug-nozzle engine.

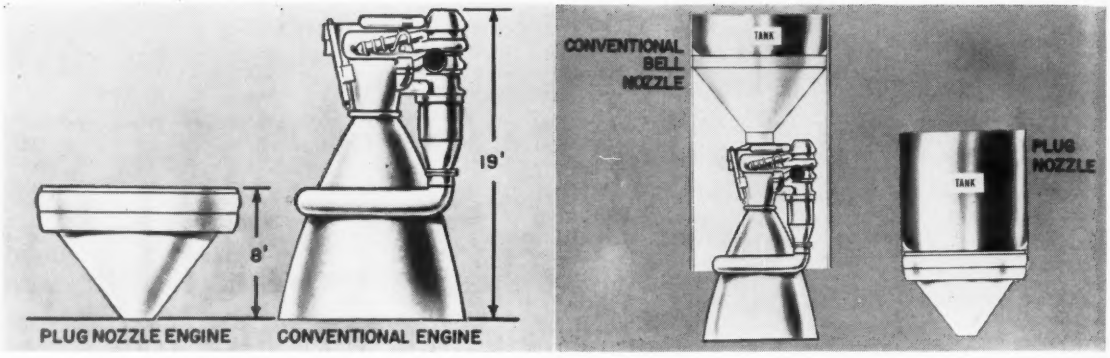
This type of engine promises a significantly shorter development cycle at substantial cost savings, as well as weight, performance, and reliability advantages over so-called "conventional designs." Although it is a radical departure from accepted engine concepts, it represents a combination of the two traditional development approaches for propulsion systems.

Should one cluster together several existing engines to reach a new thrust level, or would it be preferable to design an entirely new one using the existing model as a prototype? These are the two alternatives historically faced by the propulsion-system designer. There were major problems in both approaches which led us to believe that the answer might lie somewhere between the two.

The clustering of units has appeal insofar as it permits the attainment of any thrust level by the simple trick of tying together units with a known development history, as is done in the Saturn vehicle. This supposedly eliminates the uncertainties and costs of a new development program which must be initiated if a new larger single unit is to be built. Such considerations are not to be taken lightly. In any chemical-propulsion system, one has to deal with combustion phenomena which, to a large extent, have defied a logical scaling based on available model tests. For example, in the development of the gasoline engine, knocking or pinging was encountered and has, for that matter, remained a continual problem. More recently, rocket-engine development has been plagued by oscillatory combustion, or combustion instability. This, too, has become a roadblock toward logical scaling.

Single-Engine Dominance

In spite of the apparent advantages of the clustered approach, the trend seems to indicate that the larger single unit usually has been used more than the clustered model. One can point to the steam turbine or the turbojet as examples. The development of a 15,000-lb-thrust turbojet unit was not halted simply because any desired thrust level could have been obtained by clustering together a sufficient number of available thousand-pound units. The underlying reason for the primary emergence of single units seems to be that the smaller units, not having been specifically designed for clustering, required so much additional development to work them into a single-engine package that the attractiveness of the clustering concept largely disappeared.

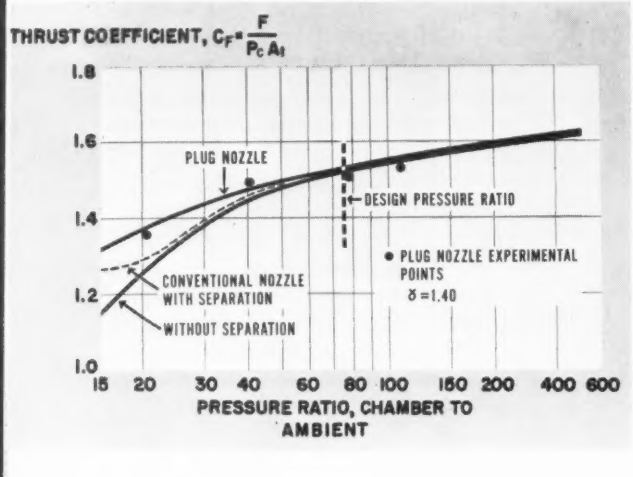


Plug-nozzle engines offer advantages of compact engine design (left) and better thrust transmission (right).

Only in the gasoline engine has the cluster principle paid dividends, principally because it became apparent that a reciprocating piston-type combustor could not be developed readily beyond a certain given size. The result was an individual combustor or cylinder design which could be easily clustered to form a single integrated engine. The modern gasoline engine, even though it may have 6, 8, or 12 cylinders, still represents a single powerplant with integrated controls and functions. Furthermore, it represents a highly reliable unit in the sense that, even if one cylinder should fail, it is still possible in most circumstances to fulfill a mission even though this may represent getting to a mechanic for repairs.

Our design philosophy, as it relates to the development of large rocket engines, follows very closely in the footsteps of gasoline-engine development. This would seem logical because, to a large extent, the problems encountered in rocket-engine development are analogous to those which have been encountered in gasoline engines. In the development of new rocket engines, a host of new mechanical design problems have been encountered, as well as the major complexities of a new combustion system.

Theoretical Performance Of Plug and Conventional Nozzles



Size Affects Combustion

Every rocket designer knows that as the diameter of the injector and chamber is increased to reach higher thrust levels, additional adverse combustion phenomena are encountered which were not present in the smaller units. Whereas in the small units the oscillatory operation occurred primarily in the longitudinal direction, the increase in chamber diameter brings on severe oscillatory modes in the tangential and radial direction.

The design of a new rocket-combustion subsystem is, to a large extent, still an art. A successful lower-thrust unit serves primarily as a tool to gain experience, rather than as a model on which to base an engineering extrapolation to the higher thrust level. This situation, when applied to the development of large-thrust rocket-engine systems, has quite far-reaching implications. All meaningful testing must be conducted with combustors of full-thrust size. Not only is this costly in terms of expenditure for hardware and testing, but it also requires a multitude of expensive high-thrust test facility complexes.

The solution of the problem, as we saw it, was either to circumvent the complex combustor problems or at least to reduce their magnitude to the point where they could easily be solved within the realm of our existing technical capabilities. Therefore, we decided to cluster the combustor, but in such a fashion that an integrated engine would still result. During the evolution of this design, it was necessary to discard some of the conventional rocket geometries. Small (CONTINUED ON PAGE 100)

One-o'clock propulsion systems

A well-known rocket engineer, anonymous out of modesty, examines a handy but misleading convention—I_{sp}, sec

ASTRONAUTICAL engineers should consider very seriously the time of their propellants. Extensive studies have led to the conclusion that at least a one-o'clock system would be required for trips to the outer solar system beyond Mars. For lunar trips and travel in the inner solar system, nuclear-fission systems of the 12:30 variety should be adequate; however, for interstellar trips even a 12:00 p.m. system or a 24-hr system would not be sufficient. For such a trip we must measure the propulsion system performance, not in seconds or hours or even days, but in years. In fact, a really adequate interstellar propulsion system should have a 9.63-yr specific impulse (photon propulsion!).

If the reader is a little confused at this point, the fault may be his own. We know that specific impulse is a measure of time (sec), and hours, days, or years are just as respectable as "sec" for this purpose.

Now, let's not quibble about whether specific impulse is really a measure of time. This is one of the most fundamental parameters of rocketry. It has been around for many years. There can't really be a second's doubt about the kind of fundamental physical quantity we are measuring, or can there? After all, if we don't have a clear understanding about such a simple and fundamental matter, how can we expect to design rockets to fly to the moon?

What It Doesn't Boil Down To

But to get back to the point that specific impulse is a measure of time. Well-known authorities in rocket propulsion—listed at the end of this note—define specific impulse or specific thrust as the impulse in pound-seconds divided by the propellant *weight* in pounds, or the thrust in pounds divided by the *weight* flow rate in pounds per second.

Now, whether we call it specific thrust or specific impulse, it boils down to pounds (force) times seconds divided by pounds (weight). But weight *is* force. So there is nothing incorrect about dividing through by pounds (force) to give seconds as our unit of specific impulse. Now, we aren't talking about the second as a unit of angle or as the ordinal number following "first." We do mean time! So we might just as well get with it and *think* time in connection with specific impulse.

All right, all right—I confess; this is a lot of nonsense and you know it as well as I do. But it sounds all right, doesn't it? Well, there *is* something funny about this time business. We start out with the burning time of the propellant and it looks as though we have come out with burning time again after canceling pounds of force. But specific impulse must be something more than burning time. Two propulsion systems with the same burning time may have very different performance and even have different numerical values of specific impulse.

Another Approach

Let's take a different approach. We all know that specific impulse is equal to effective exhaust velocity divided by g, the acceleration of gravity. But velocity divided by acceleration is time! Here we are again!

Something is wrong. So, perhaps we should return in imagination to our high school physics course, and ask our teacher, "Just what in the world is a weight flow rate?"

If the teacher is the patient, long-suffering type and doesn't throw us out of the classroom, he may explain that such a term lacks meaning. The weight of an object is the *force* of gravity acting on the object. It is a vector quantity, with direction as well as magnitude. In discussing flow rates, we are thinking *quantity of matter* or mass regardless of what we might say. When a woman wants to reduce, she is thinking of losing quantity of matter, not decreasing the force of gravity. Launching her into orbit will not give her a slimmer figure. She is thinking one thing and saying another. So are rocket experts who talk weight flow rates.

But it is argued that we commonly measure the quantity of matter in an object by measuring the force of gravity on it, and (CONTINUED ON PAGE 44)

ASTRONAUTICS Report—Part 1

Observation satellites: Problems and prospects

Useful for terrain mapping, weather reconnaissance, and international inspection, such satellites may soon be a reality . . . This introduction to the subject discusses what they might "see," the various types of sensors which could be used, and resolution and levels of observation

By Amrom H. Katz

THE RAND CORP., SANTA MONICA, CALIF.

Amrom Katz, now head of Rand's Intelligence and Reconnaissance Group, has had some 20 years of experience in all aspects of reconnaissance R&D and operations, from optical camera component development, through design and development of special techniques and concepts for field use, to design of special photo-interpretation tools and techniques. Associated with the early group of pioneers in this field, he began his career with the AF Aerial Reconnaissance Laboratory in Dayton, Ohio, in 1940 as a junior physicist in optics, eventually becoming chief physicist, and joined Rand in 1954. He was project engineer for AF photography in the 1946 atom bomb tests at Bikini, and also worked with the Far East Air Force on the solution of reconnaissance and intelligence problems during the Korean War.

This article is the first in a series based on a recently declassified Rand report in which the author discusses almost every aspect of observation satellites. Part II will cover camera systems for such satellites.

THE ORBITING of Sputnik I on October 4, 1957, was an existence theorem for satellites, removing the subject from the discussion and conjectural level and placing it on the level of actuality. The fact that satellites exist, and that more will be produced, makes the emergence and use of such special-purpose vehicles as observation satellites inevitable.

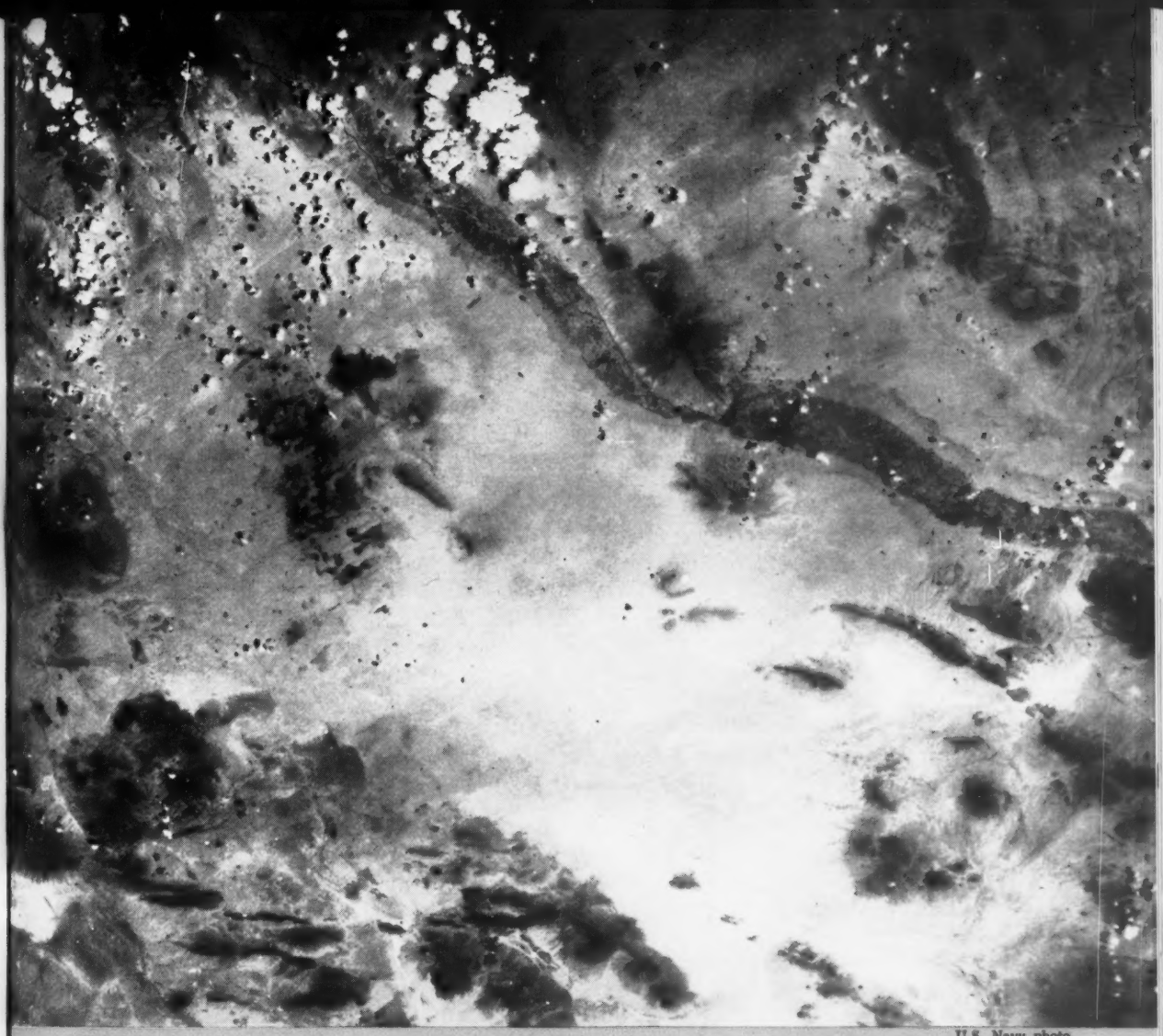
Satellites are indeed proving to be useful for making observations and collecting a great variety of data. In this paper the term "observation satellite" will largely be restricted, first, to a satellite of the earth, and second, specifically to a satellite which is instrumented to make essentially pictorial or photographic observations of the earth, its clouds, or celestial objects ranging from the moon out through the universe.

Observation satellites can be useful for the conduct of both detailed and broad inspection; for mapping of the earth and in the solution of problems of geodesy; for astronomical photography free of the image-degrading and narrow band-pass effects of the earth's atmosphere; for studies in the several earth sciences; and for meteorological observation.

Full appreciation of the role and usefulness of such satellites depends upon some understanding of the information that can be obtained and on the problems involved, the ways of getting this information back from the satellite, and the purposes which may be served by such information.

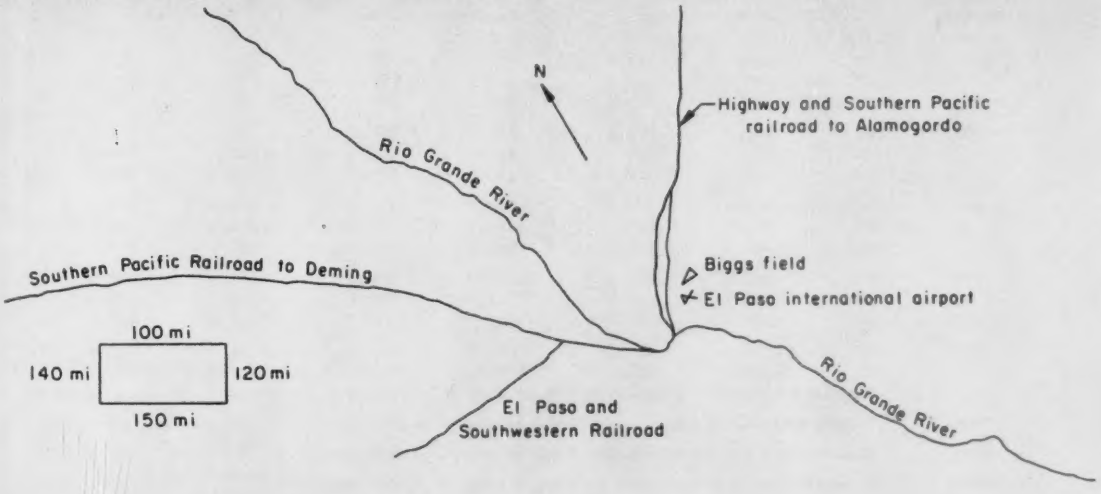
Man has always taken his vision to the high road, to places of novel perspective. When photography became a practical tool—say, a century ago—he started taking pictures from towers, mountain tops, and balloons, and later from airplanes and rockets. He still uses these camera platforms.

Aerial photography from its beginnings conjoined with reconnaissance. Nadar (1820–1910), a famous French photographer and a key figure in the history of photography, was a pioneer in aerial photography. In 1858, he started the photographic balloon ascents described in his book, *Les Memoires du Géant* (1864).

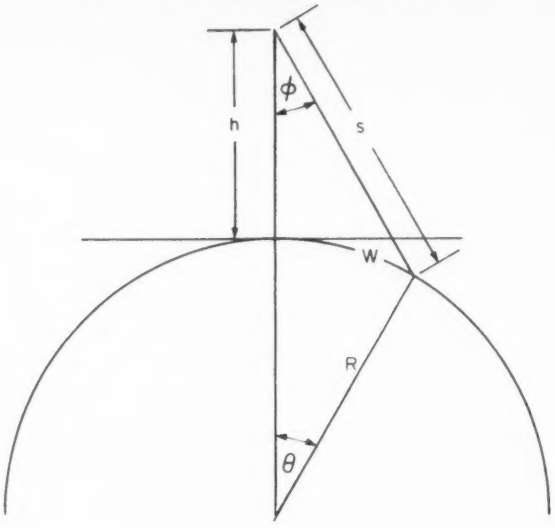


U.S. Navy photo

Photo above was taken from an altitude of 158 miles by a K-25 camera mounted in the Viking 11 rocket. Film used was infrared; shutter speed was 1/500 sec at *f*/8, with a red filter; *f*/4.5 lens with 163-mm focal length was employed. Analysis of photo is shown below. Scale around airports is about 1.5 x 10°, with a (calculated) ground resolution of about 500 ft. The fact that airfields and RR lines are resolved illustrates the caution with which calculations of ground resolution must be viewed.



Geometry of Coverage from a Satellite



Nadar's views on military applications of balloon reconnaissance changed from a refusal to work for Napoleon III in 1859 to active participation as commander of the balloon corps during the siege of Paris (1870–71).

In 1860, J. W. Black of Boston teamed up with "Professor" Sam A. King, a well-known aerialist, to take a balloon photograph of Boston from an altitude of 1200 ft. This photograph was for many years widely regarded as the most successful aerial photograph on record.

In May 1862, Gen. George B. McClellan used balloon photographs in several Civil War battles around Richmond. He made huge maps, superimposed grids on these maps, and furnished telegraph connection between division headquarters and the balloonborne observer, anticipating by about 80 years the role of aerial observers for artillery adjustment.

Greater Things to Come

All the early balloon photographers had rather small perspectives compared with the efforts and views of an American named George Lawrence (1868–1938), who started doing aerial photography from balloons and kites in the early 1900's. This remarkable man devised various cameras weighing more than 1000 lb, which took pictures as large as 4 x 8 ft, and successfully hoisted them by means of balloons, kites, and associated control apparatus to heights of several thousand feet. One of his earliest cameras was indeed a panoramic camera—a camera of the type advocated for closeup lunar photography, and one which may be useful also as a camera in observation satellites.

Lawrence was in the vicinity of San Francisco with his fantastic equipment at the time of the great earthquake and fire, April 18, 1906, thus furnishing one of the oustanding historical examples of the match between man and an event.

He hoisted his gigantic camera 2000 ft over disaster-stricken San Francisco, and obtained an 8 x $4^1/_2$-ft photograph, one of the world's most famous photographs. Seldom realized by viewers of this

Values of Slant Range *S* and Ground Distance *W* (From the Subpoint) for Various Satellite Altitudes and Viewing Ang'es

(Distances in Statute Miles)

h (statute miles)	ϕ, Deg	Based on Exact Formula *S*	Based on Exact Formula *W*	Based on Approximate Formula *S*	Based on Approximate Formula *W*	Based on Flat Earth Approximation *S*	Based on Flat Earth Approximation *W*
100	30	116.0	58.0	116.0	58.0	115.5	57.7
	45	143.2	101.2	143.2	101.2	141.4	100.0
	60	208.2	180.4	207.5	179.7	200.0	173.2
200	30	232.9	116.4	232.9	116.4	230.9	115.5
	45	290.3	205.2	289.9	205.1	282.8	200.0
	60	435.8	378.2	430.0	372.7	400.0	346.4
300	30	350.8	175.7	350.7	175.4	346.4	173.2
	45	441.6	312.4	440.2	311.5	424.3	300.0
	60	689.6	599.2	667.5	579.1	600.0	519.6
500	30	590.0	295.5	589.4	294.9	577.4	288.7
45	45	758.1	537.6	751.3	532.2	707.1	500.0
	60	1348.9	1185.7	1187.5	1032.7	1000.0	866.1
1000	30	1208.2	606.5	1203.3	603.1	1154.7	577.4
	45	1668.7	1198.1	1592.8	1133.4	1414.2	1000.0
	The maximum value of ϕ possible is 53 deg, at which W = 2558 miles.						
2000	The maximum value of ϕ possible is 41.6 deg, at which W = 3342 miles.						
5000	The maximum value of ϕ possible is 26.2 deg, at which W = 4410 miles.						
10,000	The maximum value of ϕ possible is 16.5 deg, at which W = 5075 miles.						

shot is the fact that this photograph was not made from an airplane, barely invented at this time. In fact, the camera used to make the photograph weighed much more than the Wright brothers airplane and its pilot!

It is well known that as soon as airplanes were thought to be practical and safe photographs were taken from them. Photographs in World War I, and especially in World War II, were major tools of reconnaissance and intelligence. The civil uses of photography are numerous.

It may be suspected that photography from rockets is a fairly new photographic technique. This is not the case. At a meeting in Stuttgart in 1906, one A. Bujard presented a paper, "Rockets in the Service of Photography." His paper concerned the work of Alfred Maul, who wanted to use camera-carrying rockets for military reconnaissance. He started with a camera taking pictures 40-mm square (the same size as the picture taken by the miniature Rollieflex camera). He had troubles, i.e., bad luck—the shutter would not work, the parachute would not open, etc. He finally worked up to larger models (1912) which had a stabilizing gyroscope, weighed 92½ lb at takeoff, and carried an 8 x 10 camera to about 2600 ft. But by this time the airplane was coming into its own, and photos from airplanes were easily made. The success of airplanes killed the interest in rockets as photographic platforms.

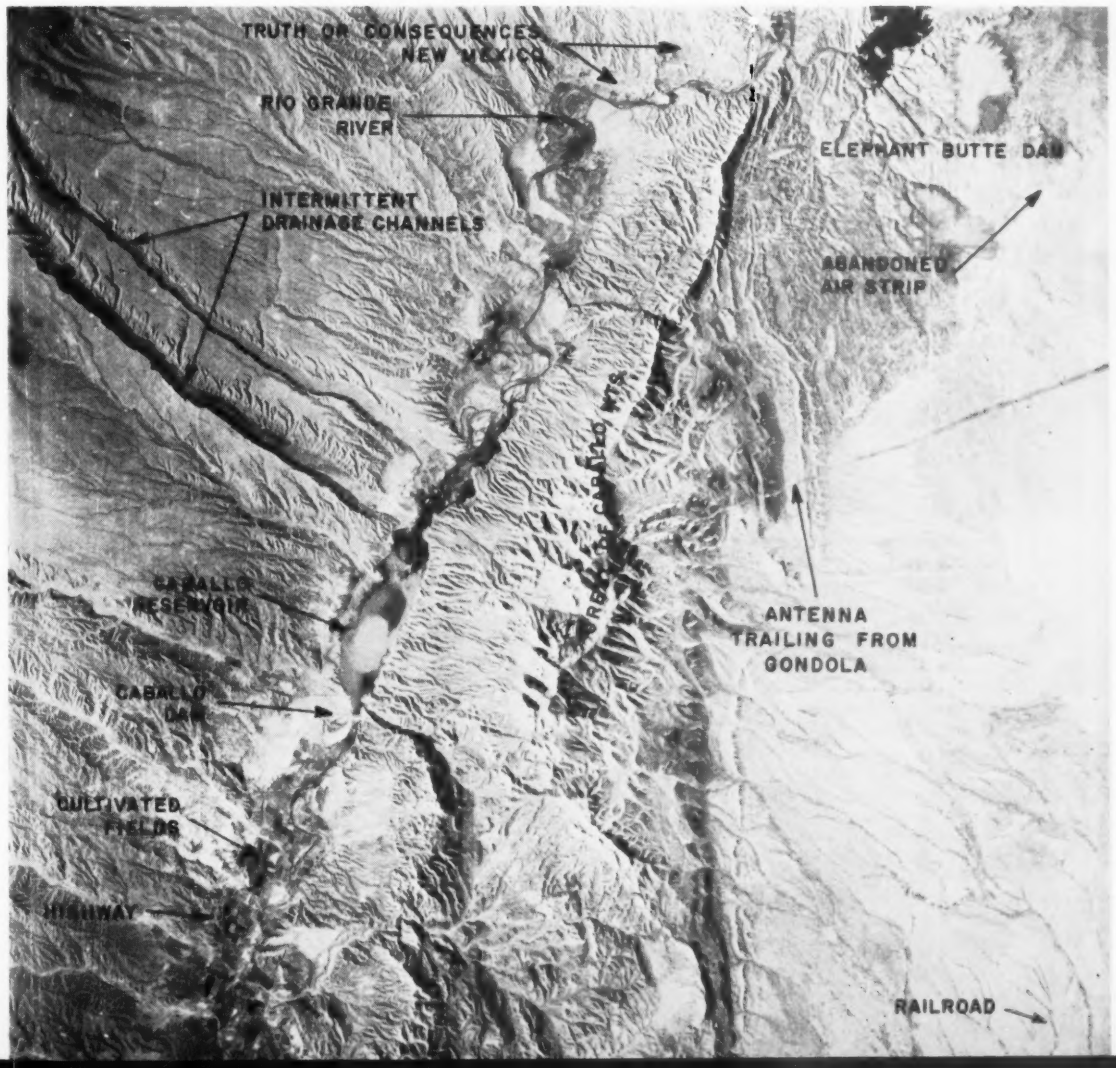
Renascence of Rocket Photography

We are now witnessing, in the current interest and activity in observation satellites, the returning swing of the pendulum.

Observation satellites may be designed to operate at various altitudes, and may have varying viewing angles. (CONTINUED ON PAGE 74)

Photo taken from balloon at an altitude of 87,600 ft, using camera with 1.5-in. focal lens, Aero Super XX film, and exposure of 1/500 sec at *f*/11, with Wratten 73 filter.

USAF photo



The composition of outer space

A larger view of the solar wind and its interaction with earth, earth-atmosphere and interplanetary constituents, and associated phenomena begins to emerge from our new study of space

By Francis S. Johnson

LOCKHEED AIRCRAFT CORP., PALO ALTO, CALIF.

Francis Johnson, manager of space physics research at Lockheed's Missiles and Space Div., received a B.Sc. degree in physics from the Univ. of Alberta in 1940, an M.A. degree in physics-meteorology from UCLA in 1942, and a Ph.D. in meteorology from UCLA in 1958. After serving in the Air Force as a weather officer from 1942 through 1945, he joined the Optics Div. of the Naval Research Laboratory, where he worked in the upper-atmosphere rocket research program from its beginning, in 1946, until 1955, when he joined Lockheed. Dr. Johnson has made numerous contributions to the field of space physics, especially on solar ultraviolet radiation, and on atmospheric and ionospheric structures.

THAT PART of galactic or interstellar space through which the solar system moves is generally accepted as containing about 1 hydrogen atom per cc. This information is obtained from the observation of 21-cm radiation from hydrogen in interstellar space, which has made it possible to map the density and velocity of hydrogen through a substantial portion of our galaxy (Brown and Lovell, 1958). The narrowness of the emission line shows that the hydrogen is characterized by a temperature of about 125 K; hence, it should be negligibly ionized.

In interplanetary space, i.e., within the solar system, the particles are predominately of solar origin. It is believed that the solar corona consists of outstreaming gas, which, at the earth's distance from the sun, usually consists of about 100 protons per cc and an equal number of electrons, both moving with a velocity of about 500 km per sec (Biermann, 1953). Under disturbed solar conditions, this may rise to 10^3 or 10^4 or very rarely even up to 10^5 protons and electrons per cc moving with a velocity as high as 1500 km per sec. The kinetic energy of the protons in this stream, which is generally referred to as the solar wind (Parker, 1958), varies between 2 and 20 kev. Since these energies are much greater than the potential energy of the particles in the solar gravitational field, the velocities are not significantly influenced by the motion through the gravitational field of the sun, and the concentration of the particles must vary inversely as the square of the distance from the sun. Thus, under quiet solar conditions, the proton concentration in the solar wind at 10 astronomical units (A.U.) from the sun should be down to about 1 proton per cc. As this concentration is comparable to the concentration of hydrogen atoms in galactic space, the interplanetary medium can be said to be merging with the interstellar or galactic medium at this distance from the sun.

Influence of Solar Wind

As one moves from interstellar space into the solar system, the concentration of hydrogen atoms drops from its average value of about 1 atom per cc in galactic space. The reason for this is that the energetic protons in the solar wind have a large cross section for colliding with and exchanging charge with the galactic hydrogen atoms (Fite, et al., 1958). After a charge-exchange collision between a solar-wind proton and a galactic hydrogen atom in the

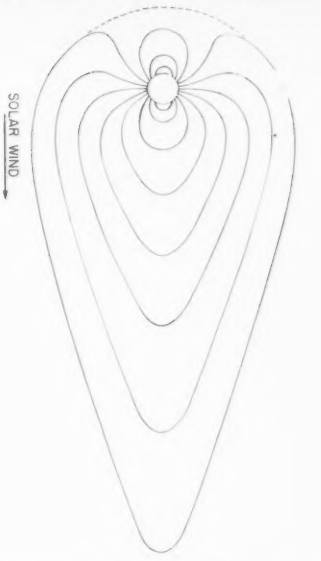
vicinity of the solar system has taken place, the hydrogen atom has a high outward velocity which rapidly removes it from the vicinity of the solar system, and the proton has a low velocity characteristic of an interstellar hydrogen atom.

The lifetime for neutral hydrogen atoms in the solar system before being hit by a solar-wind proton varies directly as the square of the distance from the sun, and, near the earth's orbit, has a value of about one day. At times when the solar wind is enhanced, its effectiveness in sweeping hydrogen from the solar system is increased by 2 or 3 decades. Thus, the hydrogen concentration in the solar system within 1 or 2 A.U. of the sun must be quite small—almost certainly less than 10^{-2} atom per cc, and probably much less.

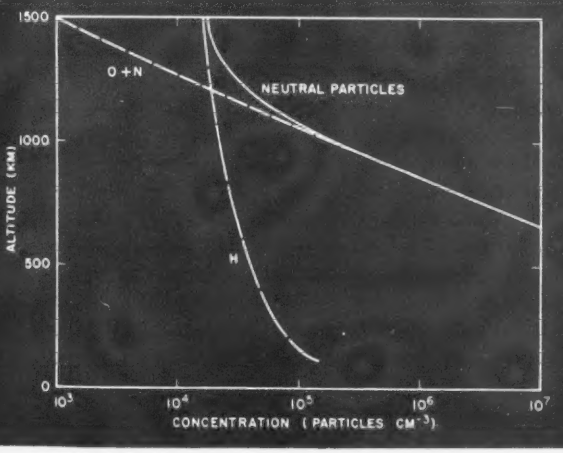
The medium through which the earth and its atmosphere moves is thus the somewhat variable solar wind, consisting of 10^2 to 10^4 protons and electrons per cc. Although not detected, other solar gases may be present in characteristic solar abundances; if so, the principal additional constituent would be helium nuclei. The solar wind streams past the earth with a hypersonic velocity roughly of the order Mach 10 to 100. The exact value cannot be specified since the temperature of the plasma constituting the solar is not known.

The solar gas through which the earth moves cannot penetrate the geomagnetic field. A cavity, which (CONTINUED ON PAGE 92)

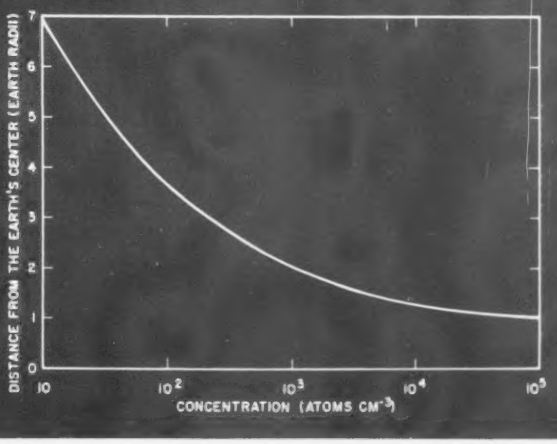
Earth's Magnetic Field as Deformed by the Solar Wind
(Boundaries must be turbulent)



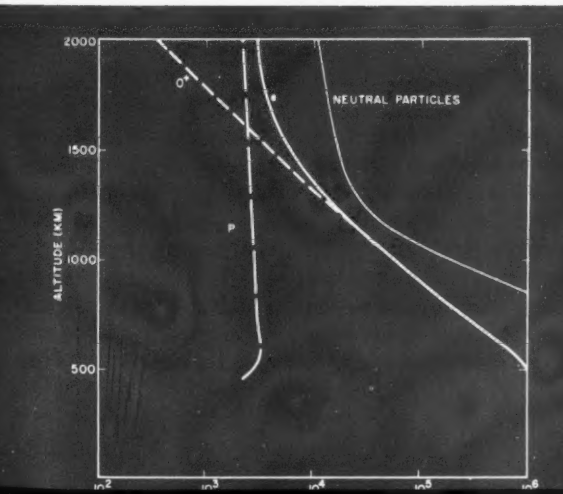
Distribution of Neutral Particles in the Upper Atmosphere



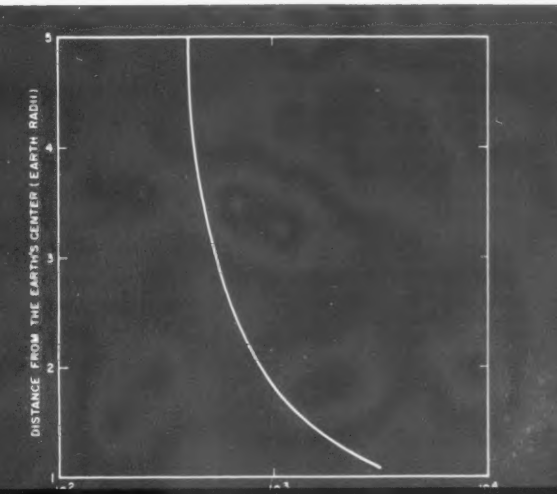
Distribution of Atomic Hydrogen Near the Earth



Distribution of Ions in the Upper Ionosphere



Distribution of Protons and Electrons in the Protonosphere



Extraterrestrial life

Man as a species may be unique, but there is good reason to expect habitable planets with higher forms of life in other solar systems

By Harlow Shapley

HARVARD UNIV., CAMBRIDGE, MASS.

Harlow Shapley first approached the subject of life on other planets in his slim little best-seller, "Of Stars and Men," published by Beacon Press in 1958. An internationally famous astronomer, Dr. Shapley was on the staff of the Mt. Wilson Observatory for seven years and from 1921 to 1952 was director of the Harvard Univ. Observatory. Currently lecturer on cosmography in the Astronomy Dept. at Harvard, he holds honorary degrees from 15 universities throughout the world and has been made an honorary foreign member of the national academies of science of 10 foreign nations in recognition of his outstanding contributions in the fields of photometry, spectroscopy, and cosmogony. A past president of the American Astronomical Society (1943-46), he is the author of half a dozen books and hundreds of scientific articles.

NO LONGER need we leave the question of extraterrestrial life to the science-fiction writer. Scientific discoveries and cosmic probes have made it possible to do some tighter thinking on this subject. But first we must recognize that "life" can be variously defined; and clarity for the term is advisable before we report on the relevancies and speculate about the answers.

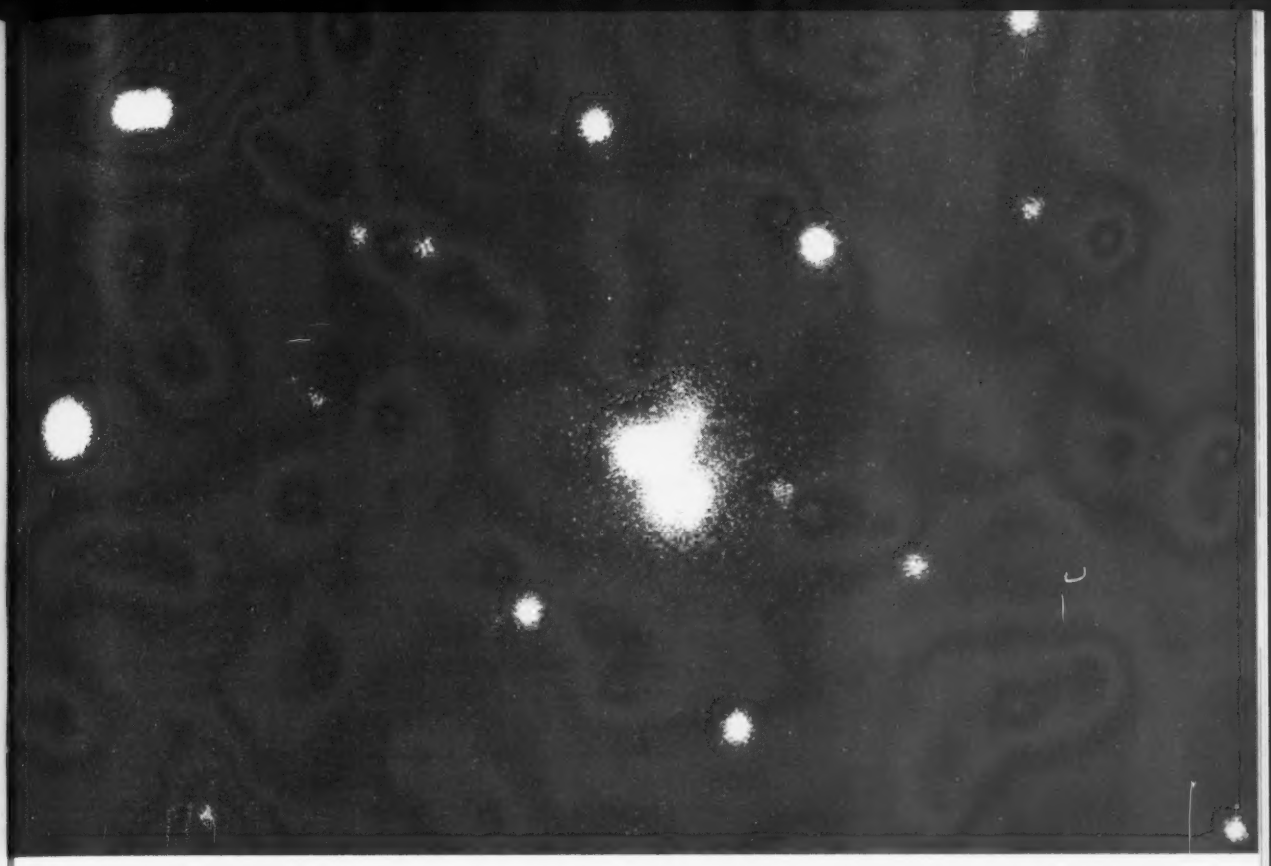
In our chosen narrow definition, let's forget about the liveliness of the atoms we breathe, the fast and brief life of electronic states, the vigor of creeping ice sheets, and the energetic rotations of stars and galaxies. In a broad sense, all things and subthings that take part in animate and inanimate evolution are *alive*, for they originate, grow, decay, become dormant, or die. We can narrow the field of discussion by speaking of self-replicating macromolecules. In fact, we are mostly concerned with something "higher" than the primeval self-replicating macromolecules. Organisms such as we recognize as living (or recently alive) on the earth's surface will be the life examples that concern us here.

Two preliminary remarks are necessary. First, we cannot yet positively deny, on the basis of observation or of biochemical theory in its present stage of development, that life might also be based on chemical elements other than those predominant in terrestrial organisms. Life might also exist in physicochemical and climatological conditions quite unlike those on earth. Second, conditions of air, water, or soils that would poison all terrestrial plants and animals might be endured on Mars or elsewhere by organisms that originated and developed under conditions impossible for us. For example, lichens from our arctic rocks might perish promptly if transferred to the Martian rocks, but nevertheless Martianbred lichens probably do exist, and they in turn might wither and perish in our relatively hot arctics and burn up in our oxygen-rich atmosphere.

Definition of "Habitable Planets"

By "habitable planets" we could choose to mean planets populated with "humans," or we could mean planets capable of producing and maintaining the protista (protozoa, protophyta) and also, when conditions are right, capable of producing the higher subhuman organisms.

As to the human existing elsewhere, I take a very dim view. The exact duplication of *homo sapiens* is a very long shot, even in this chance-rich universe of stars, space, time, and energy. There are



Unseen but detectable through gravitational effects, a body in 61 Cygni (above, center) is the only planet definitely discerned outside our solar system. Photo taken by 200-in. telescope of Mt. Wilson and Palomar Observatories.

hundreds of thousands of known variations on the animal theme. Innumerable distinct forms have long thrived but eventually failed to survive environmental hazards. At best, they are now fossils in the rocks, and at worse they are undifferentiated constituents of the generalized dust, water, and gas near the earth's surface. Probably by many a narrow squeak we of the *homo sapiens* species adjusted to successive environmental changes. Many of our anthropoid forebears did not.

As to planets supporting any kind of protoplasmic reactions—I would put it that living organisms are, and in fact must be, widely spread throughout the known universe. Their occurrence is a natural, even an inevitable, product of molecular evolution.

All the stars are in motion with respect to each other. Their distances are so great, however, that the actual motions on the surface of the sky are so small that much precise labor is required to measure them at all. Only for a few of the nearer stars is a fair accuracy attained. A double star in Cygnus, with the catalogue number 61, is near enough for its transverse motion to be recorded as sinusoidal. The body that produces gravitationally this wavelike deviation from essentially straightline motion is not seen. The similar wavy motion for stars like Sirius and Procyon is explained by the presence of companion stars faintly seen. The bright star and its faint companion are going around a common center of gravity, just as the earth and moon are revolving in a period of a month around a common center of mass, which lies 1000 miles below the earth's surface. Actually, 61 Cygni's unseen companion—unseen but gravitationally demonstrated—is the only definitely recognized planet outside the solar system. From its gravitational action on its primary, we believe the companion to be considerably larger than any of our planets. In fact, it might be called a very dwarfish star or a superplanet. Some day we may measure its faint long-wave radiation—"discover" it, that is, with a radio telescope.

Evidence Supports "Habitable Planets"

With only 61 Cygni's "planet" certain, and not too positively accepted as such, our considerations of the existence of life-bearing planets among the stars must therefore be based not on observation, but on circumstantial evidence. This evidence, however, seems to me to be powerful. I can take time and space here to cite only sketchily the developments that in the (CONTINUED ON PAGE 50)

Multistart rocket engines

Re-startable engines have become a "must" for certain space missions . . . Here's how they work, plus several different methods of turning the trick

By Kurt R. Stehling

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D. C.

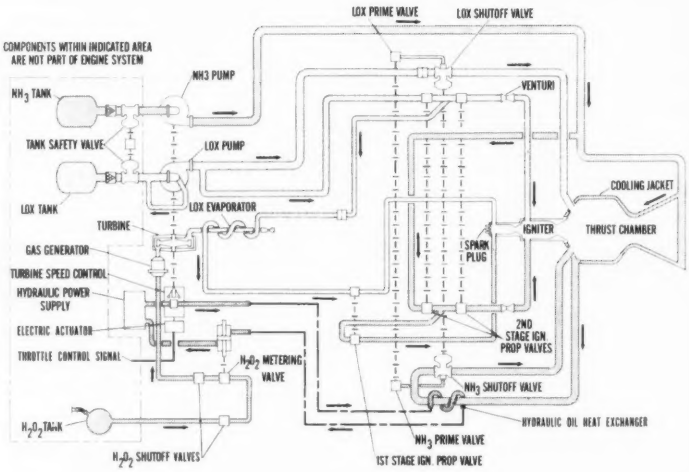
THE "CLASSICAL" rocket engine is usually thought of as a device whose operational cycle starts with ignition and combustion and runs through to propellant exhaustion. Indeed, for most rocket applications a single-ignition, or one-start, engine is all that is necessary. The engine designer, who would rather sidestep ignition problems, starts even large, sophisticated rocket engines in a rather primitive manner. Usually, no more than a pyrotechnic ignition squib is employed, and really not much more is needed for the case where the engine starts and proceeds undisturbed to propellant burnout.

However, with the growth of rocket technology came the need for more versatile systems, such as multistart engines. Beginning with the hydrazine-hydrogen peroxide powerplant in the German rocket interceptor, the ME 163, and proceeding through the AF-Bell Aircraft X-1 and X-2 rocket airplanes, a series of re-startable engines was designed and operated.

We immediately see here a powerful incentive for the use of a re-start system. A manned rocket vehicle (or rocket aircraft) must have enough engine flexibility to permit the pilot at least a start-stop-start capability, to say nothing of such other desirable features as throttling. With the pilot on board, the decision for

Kurt Stehling is now scientist for rocket propulsion in NASA's Office of Program Planning and Evaluation. He was formerly head of the Vanguard Propulsion Group at NRL, charged with supervision of powerplant development for the project. A graduate of the Univ. of Toronto, he did work on high-altitude infrared spectrometry and combustion phenomena while with the American Optical Co. in 1949–50; was a rocket research engineer with Bell Aircraft from 1950 to 1953; did research at Princeton's Forrestal Research Center in 1953–54; and was acting group leader of Bell's Fluid Mechanics and Heat Transfer Rocket Section prior to joining NRL in 1955, moving to NASA when the Vanguard project came under the agency's direction.

Schematic Drawing of Basic RMD XLR99-RM-1 Engine



re-starting is, of course, in his hands. If a guided missile or unmanned space vehicle needs re-start capability, such a function must be exercised by a complex of telemetered commands and servo-actuated flow controls.

While manned rocket aircraft demand re-start capability, there are some other uses for such a propulsion system, as shown in the table on page 36. The most powerful arguments for the development of a re-start engine system lie in the need for such a system in the earth orbit apogee "kick," and in planetary and lunar orbits and "soft" lunar landings. At least, during the next half-decade or so, there will be a growing demand for re-start capability development in these areas.

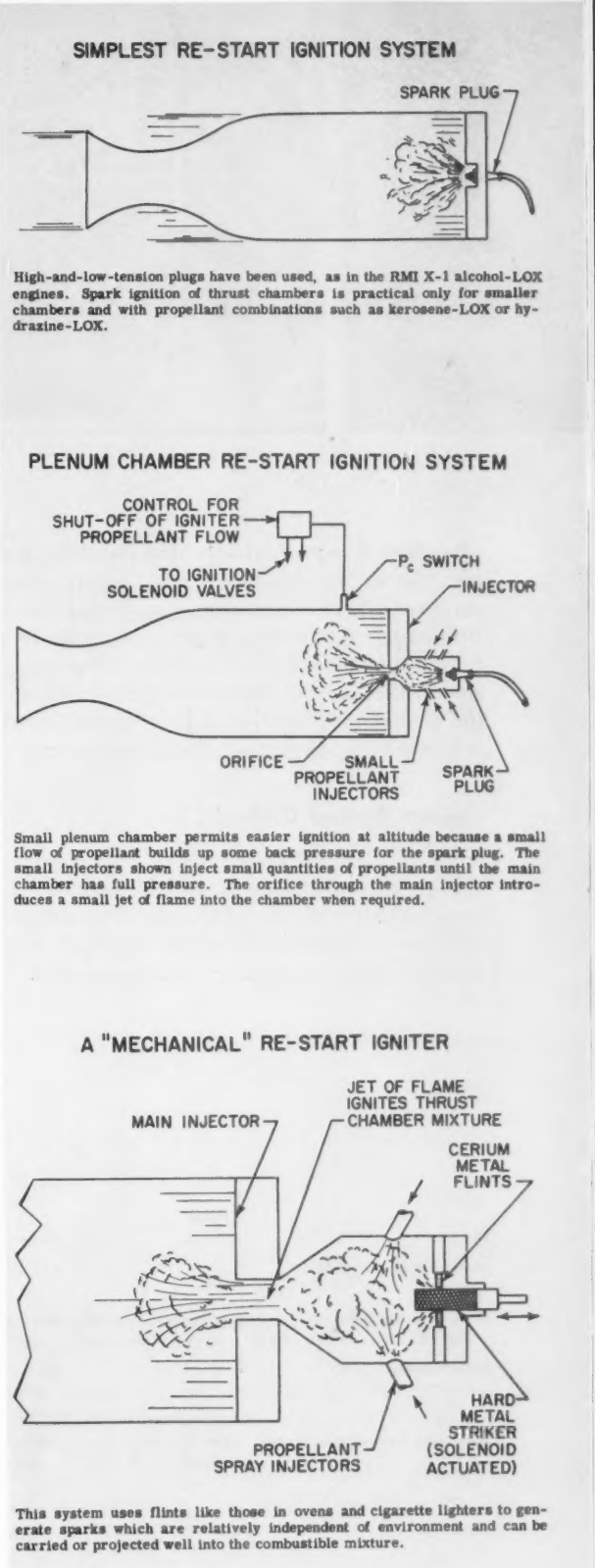
It is one thing, of course, to talk about the need for re-start, and another to design a system that will work reliably in the hostile environment of space or after long exposure to this environment, and perhaps under conditions of no-gravity, or during the critical phase of a lunar approach or a precise maneuver in an earth orbit.

No Single Design Concept

The lack of standardization in the rocket engine and propellant business and the multifarious uses and applications involved prevent a single design concept from being applied. In general, though, it can be said that an ignition system and the auxiliary pressurization and pumping elements have to be tailored specifically for re-start. It is not simply a matter of closing down the main propellant valves in an engine system and then opening them whenever re-start is required. A rocket-thrust chamber, despite its apparent simplicity, requires delicate handling if it is to survive such rigorous use.

For instance, on shutdown of the engine, somewhere in space, say, we can assume that, with good design, it is possible to effect a "clean" shutdown without surges or chamber burnouts. If the chamber is regeneratively cooled, the coolant must not, or should not, be absent during the last moment of combustion, nor should the coolant jacket be empty on re-ignition. Furthermore, if the engine has been shut down for some time, how have seals and connectors fared in the pressurization and/or pumping system? The injector and adjacent manifold should have been purged of residuals so that on re-start explosive mixtures are not formed behind the injector face. If purging has been accomplished, there must be enough purge gas left for re-start.

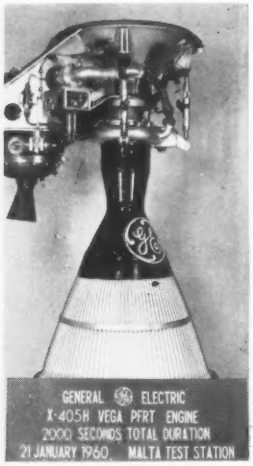
While it is possible to keep propellant gas turbine pumps operating between engine ignitions through such means as bypassing circuits, etc., such a scheme involves needless consumption of propellants and, of course, results in wear and tear on the pumps.

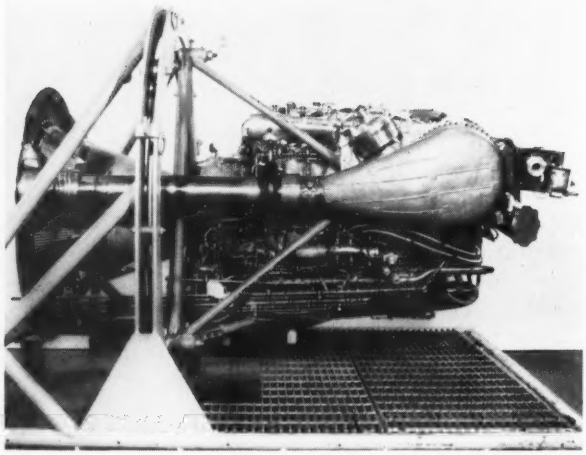


High-and-low-tension plugs have been used, as in the RMI X-1 alcohol-LOX engines. Spark ignition of thrust chambers is practical only for smaller chambers and with propellant combinations such as kerosene-LOX or hydrazine-LOX.

Small plenum chamber permits easier ignition at altitude because a small flow of propellant builds up some back pressure for the spark plug. The small injectors shown inject small quantities of propellants until the main chamber has full pressure. The orifice through the main injector introduces a small jet of flame into the chamber when required.

This system uses flints like those in ovens and cigarette lighters to generate sparks which are relatively independent of environment and can be carried or projected well into the combustible mixture.





Far left, GE's X-405H re-startable engine, designed for Vega vehicle, and (left) Reaction Motors' XLR99-RM-1 Pioneer turborocket engine.

Therefore, it is preferable to shut down the pumping system simultaneously with thrust chamber stoppage. This means more complicated flow controls and stopping the gas generator, with re-ignition of the latter on re-start. Also, the pumps take some time to reach maximum rpm, which means the re-start program should be triggered by a rise in pump outlet pressure to the design value.

Ignition System Critical

The ignition system or, rather, ignition of the combustibles in the thrust chamber, is a critical element in any re-start scheme. If hypergolic propellants are used, an auxiliary igniter, such as a spark plug, is, of course, not needed. It is thus natural that hypergolic propellant combinations, such as hydrazine and nitric acid, are favorites for re-start engines.

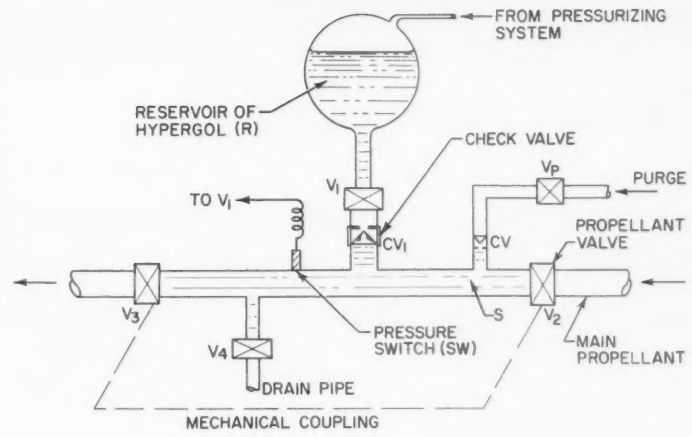
It should not be assumed that there are no problems with such propellants. Hypergolics suffer from ignition delays at low temperature (which may be encountered in space) and, under the peculiar conditions of vacuum starting, severe transients may occur on ignition. The ignition of the second-stage Vanguard engine, while usually successful in vacuum, was occasionally accompanied by violent starting surges. These weren't destructive, but they threw an extra burden on the control system. For manned rocket applications, hypergolics are not so desirable because of safety hazards, although these

Re-Start Applications

Use	Typical Vehicle	Engine	Re-Start Technique	Re-Starts Required	Problem Or Need
Manned Rocket Vehicle	X-15	RMI 50K thrust	Electric plus aux. chamber	Several	Pilot's control over his powerplant
Earth Orbit Correction (For Circular Orbits, etc.)	Discoverer (or Agena) or Vega (cancelled)	Bell Aircraft ("Hustler" derived	Hypergolic slug or propellants	One	Orbit correction
Lunar Landing	—	Medium thrust preferably with throttling capability	Any discussed approach is suitable	Several	Payload braking based on payload-lunar approach rate
Lunar and Deep-Space Probes	Thor Atlas-Able (previous) Juno II	Small solids or hydrazine aux. engines	Actually multistart small solids or hydrazine chamber fired until proper velocity increment was obtained	Several, very precisely timed	Precise orbit injection or midcourse maneuvers

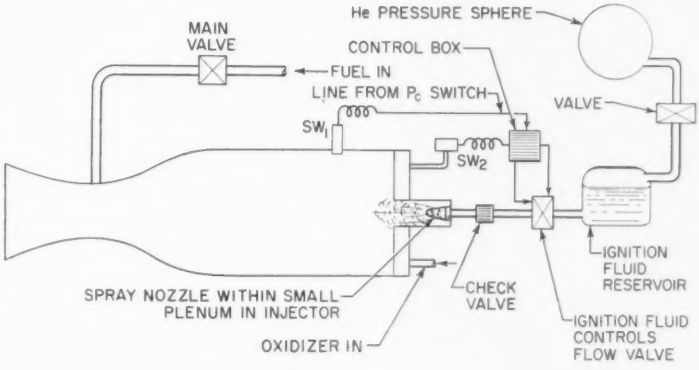
AUXILIARY RESERVOIR OF HYPERGOLIC LIQUID IN ONE PROPELLANT LINE

A hypergolic slug of liquid, such as fluorine, can be injected as a leading slug on re-start. Sequence: (1) Pipe volume (S) is filled and bled before start from R, and V_1 (valve) and V_4 (drain) are then closed; (2) V_2 and V_3 open on start, main propellant flows and drives slug ahead; (3) on command shutdown, V_2-V_3 are closed, V_4 open and V_p open, purge on; (4) V_p is closed, V_4 open to overboard and V_1 open. Hypergol flows and fills S until CV_1 is balanced and SW senses the pressure, V_4 shuts and closes V_1. Slug is now loaded and ready to begin re-start cycle. (Note: CV_1 is not absolutely necessary but helps control flow from R.) SW is activated only during refill cycle.



ANOTHER AUXILIARY HYPERGOL RE-START INJECTION SYSTEM

This system is independent of any flow in a pipe. It is triggered on command and shuts down when P_c rises to required value. P_c switch SW_1 gives the shutoff command for the auxiliary system. In operation, the ignition fluid control flow valve (solenoid) is shut off by P_c signal and re-opened by command, all from the control box. Start can be achieved by SW_2 when propellant flows initially. Then rise in P_c will result in shut-off. In this scheme, external command to main propellant valves would start the system and shut it off automatically. Control box design would be tricky.



may be minimized by good handling techniques and safety precautions.

When nonhypergolics are used, there are several possible methods of ignition:

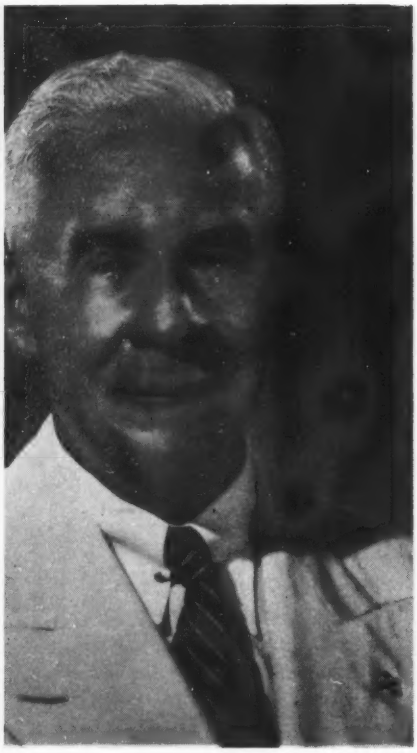
The spark, or glow, plug shown in the top drawing on page 35, has a long history of use in other engines, and at first glance seems a natural device for the rocket engine. Re-start on the lox-alcohol chambers of the X-1 airplanes was accomplished by using specially designed plugs. Apparently the injection of unburned propellant vapors into a chamber usually builds up enough back pressure to permit plugs to function. Electrical glow plugs are also suitable for this purpose but do not yield as much ignition energy transfer to a given volume of vapors. The spark plug has the disadvantages of corona-arcing and electrical leakage in a partial vacuum. As stated earlier, some chamber pressure is achieved by purging or propellant bleeding; this usually allows spark buildup. Certain propellant combinations with nitric acid tend to ionize the atmosphere around the plug and quench the spark.

Drawbacks of Spark and Glow Plugs

The electrical spark, or glow, plug therefore suffers from a number of disabilities, not the least of which is the inability to transport ignition energy to a sizable mixture of combustible gas or gas-liquid volumes. However, for *small* re-startable rocket chambers, they have some merit. A derivation of this is the use of a small, separately ignitible ante- or auxiliary chamber that (CONTINUED ON PAGE 102)

Oldest ARS member?

Daniel Wells, one of only two surviving charter members of the Aero Club of Michigan, becomes a member of the Detroit Section at age 84



Daniel Wells

DANIEL WELLS, who celebrated his 84th birthday in March, may well be the oldest ARS member. One of only two surviving charter members of the Aero Club of Michigan, founded shortly after the Wright brothers carried out their initial experiments at Kitty Hawk in 1903, Mr. Wells recently became a member of the Detroit Section at the invitation of the Section's president, E. A. Nielsen of Chrysler Missile Div.

In a letter to Nielsen, Mr. Wells wrote: "We were formed as a club of 90-odd members to get behind the Wright brothers and launch them into the world—this, when there were only about a dozen airplanes in the whole world. For some occult reason, Providence decreed that we should be in at the birth of the Aviation and Space Age . . ."

Last September, at a luncheon of the Economic Club of Detroit co-sponsored by the Michigan Aeronautics and Space Assn. (formerly the Aero Club), Allen B. Crow, president of the Club, read briefly from an article Mr. Wells had written a year earlier, entitled "From Kitty Hawk to the Moon," which reviewed the many changes which have taken place since the Wright brothers first took to the air. The concluding lines of the article: "Truly, we had come a long way from the historic sands of Kitty Hawk to shooting at the Man in the Moon."

Mr. Wells recalls that the featured speaker at the luncheon was T. Keith Glennan, NASA Administrator, and commented in his letter to Nielsen: "His annual budget . . . is $800 million. If the Wright brothers heard that, they would think we were demented. We could tell them we were only starting."

The letter goes on: "In my time, I have heard serious, competent men discussing the possibility of a round trip from the earth to Mars. Then, 60 years ago, I heard men seriously discussing the possibility of a return flight (from Detroit) to Birmingham, Mich.

"I recently joined the Circumnavigators Club of New York and elsewhere. To be a member you must have made a complete circuit of the globe.

"In the future, we will have a Space Navigators Club. To be a member, you will have to have been . . . on the moon, or at least to have made your first trip to Mars.

"Let me say again . . . that I appreciate the honor you are according me in allowing me to become a member of your distinguished organization, scientific center of the study that means so much to the future of this country."

And, in keeping with the eternal youth of the man, who at 84 serves on the Wayne County Selective Service Board and, in the course of a recent trip to Hawaii, astonished the natives with his swimming feats, his letter signs off with a simple "Yours for the Age of Space, Daniel Wells." ♦♦

The R&D proposal

Now, as never before, the private industry or institution must respond with knowledge, skill, and creative planning to bid successfully for Government research and development contracts

By John V. E. Hansen

NATIONAL RESEARCH CORP., CAMBRIDGE, MASS.

John V. E. Hansen received his B.Ch.E. degree from Brooklyn Polytechnic Institute in 1949, and has done graduate work in chemical engineering, physics, electronics, and business administration. Active in government procurement and contract work since 1951, he has been responsible for proposal preparation and contract administration at National Research, where he is now contracts manager, for several years, and is the author of a number of articles on engineering administration and government procurement. An Associate of Simmons College, he has lectured at Tufts College, was one of the founders of The Society of Technical Writers, and is an ARS member.

IT WOULD be interesting to have an accurate accounting of the money that goes into preparing and submitting proposals to the Government in the course of a year under our present procurement system. The remark that "5 percent of our scientists are working on contracts and the rest on proposals" is, hopefully, an exaggeration; yet there can be no doubt that a prodigious effort is expended every year, both by creative scientists and engineering management, in preparing proposals.

From an engineering management standpoint, the preparation and submission of a proposal is an investment. The decision to make this investment is made on the same basis that any decision is made to undertake a business venture: If the cost is considered warranted in view of the potential return, a proposal is underway.

Survey Shows 10 Percent Reached Contract Stage

As a rule, the return on these proposal investments is less than 25 percent, and probably less than 10 percent unless the organization is unusually fortunate. Some substantiation for this can be found in statistics compiled by the Government. At one of the largest Government facilities in the country—from the standpoint of awarding R&D contracts—a survey four years ago revealed that approximately 3 percent of all proposals, both solicited and unsolicited, were reaching the contract stage. A 1959 survey showed that approximately 10 percent of current proposals were resulting in contracts. This increase is heartening, but it is apparent that the return on the proposal investment is still fairly low.

Since many companies have a sincere desire to apply their talents and facilities to Defense Dept. problems by undertaking research and development programs, and since such programs must originate with proposals, it behooves us to look at this problem from an engineering management standpoint. In short, we would like to improve our proposals. To do this, we can ask some fairly general questions.

(1) What are the criteria for deciding whether or not to submit a proposal?

(2) What are some of the ground rules for preparing R&D proposals?

(3) On what basis are they evaluated? (CONTINUED ON PAGE 86)

Thermal protection of space vehicles

The near-steady heating conditions encountered in long-term spaceflight have sparked development of integrated systems designed to protect the vehicle while combining maximum insulating effectiveness and low weight

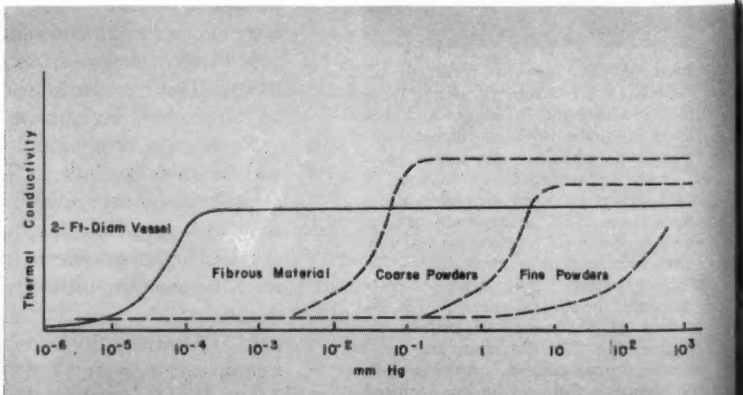
By Peter E. Glaser

ARTHUR D. LITTLE, INC., CAMBRIDGE, MASS.

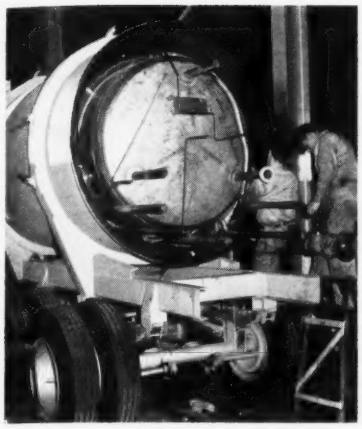
THE IDEA of scaling the thermal barrier, so often discussed publicly, conjures up visions of a brilliantly glowing nose cone successfully resisting aerodynamic heating while re-entering the earth's atmosphere. Although space vehicles encounter their most severe problems during this brief period, they must, in addition, overcome the less severe but also less obvious problems created by aerodynamic heating in extended flight through the upper atmosphere, by solar radiation, or by internal heat generation. Consequently, most of the approaches favored by nose-cone technology are not applicable.

The problems generated by these nearly steady heating conditions have sparked the development of an integrated system designed to protect various parts of a space vehicle. This system must combine maximum insulating effectiveness with the lowest possible weight. Unlike most present insulations, a thermal protection system is usually a combination of materials which, besides providing maximum insulating effectiveness, gives structural strength without imposing too great a weight penalty. The advantage of a thermal protection system is that the insulating function and the load-carrying elements can be designed separately. The insulation can be designed to withstand the predicted heating conditions, and the load-

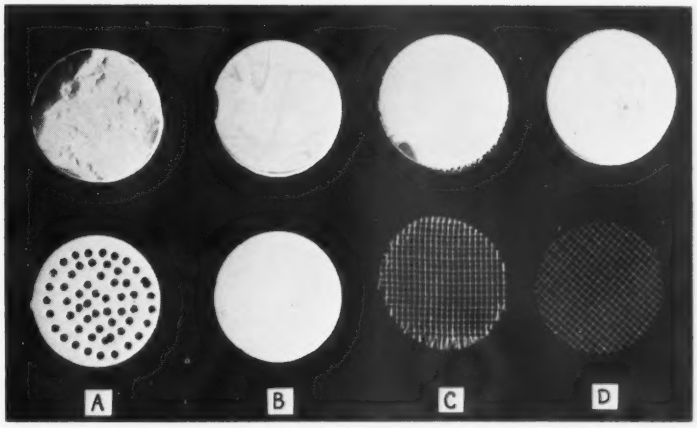
Peter Glaser received his undergraduate training in mechanical engineering at the Leeds College of Technology in England and at Charles Univ., Prague, Czechoslovakia. He obtained his M.S. in 1951 and a Ph.D. in mechanical engineering in 1953 at Columbia Univ. Since joining Arthur D. Little in 1955, Dr. Glaser has worked on such problems as development of more efficient thermal-insulating systems, thermal-properties measurement, temperature measurement, temperature-measuring instruments, and heat-exchanger analysis, and has developed an electric-arc imaging furnace now in use on several high-temperature research projects.



RELATIONSHIP OF PRESSURE TO THERMAL CONDUCTIVITY FOR SUBSTANCES OF VARIOUS PARTICLE SPACINGS



In one approach designed to assure structural integrity of a thermal protection system, insulation is placed in a space between two pressure vessels, as shown here. This approach is being used with cryogenic propellants.



Multiple-layer radiation insulation: (A) Tempered aluminum foil (0.00025 in.) and perforated fiber glass mat (0.008 in.); (B) tempered aluminum foil (0.002 in.) and fiber glass mat (0.008 in.); (C) tempered aluminum foil (0.002 in.) and fortisan-acetate, mesh 1/10 x 1/10 (0.010 in.); and (D) tempered aluminum foil (0.002 in.) and resin-covered fiber glass, mesh 1/8 x 1/8 (0.020 in.).

carrying elements can be designed to withstand outside forces, such as aerodynamic loads, vibration, acceleration, thermal shock, and particle erosion. The insulation and load-carrying elements can then be combined to form the vehicle structure.

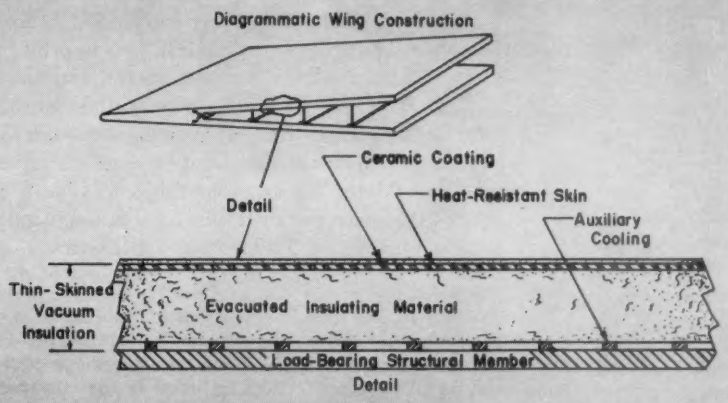
For Various Heating Conditions

Thermal protection systems can be used under different heating conditions, as, for example:

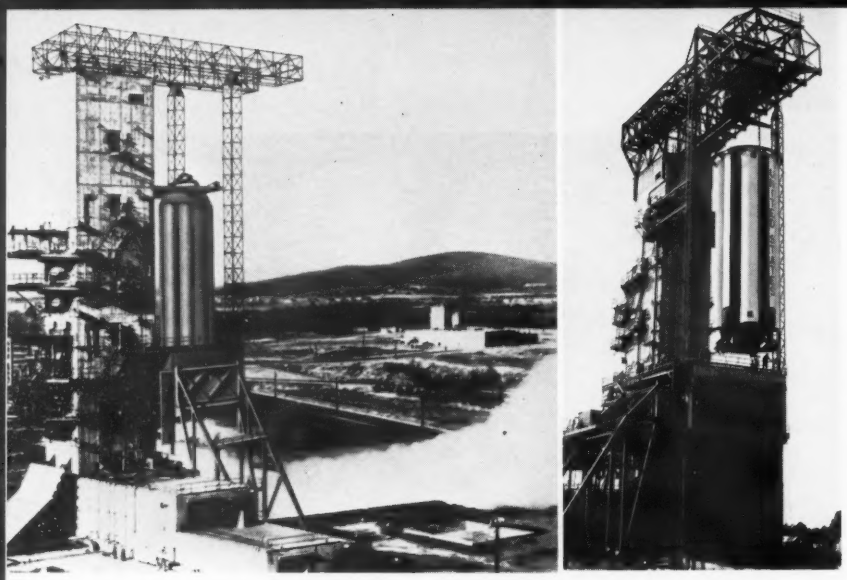
1. Prior to flight, to reduce the boiloff rates of cryogenic propellants.
2. During flight, to protect the vehicle structure, propellants, occupants, and instruments from the effects of aerodynamic heating or solar radiation.
3. While in orbit or deep space, to provide thermal control over the space-capsule environment.

Heat flows from the warmer to the colder surface of an insulating material by (1) conduction through the solid portions; (2) conduction or convection of the gas filling the spaces between the particles; or (3) radiation across these spaces and through the solid matrix. Although these heat-flow mechanisms are well understood individually, their combined effects are still being investigated. The individual conductivities of each mechanism, however, can be minimized at various temperatures and pressures.

Heat conduction through the solid insulating material can be reduced if the conduction paths are broken up with finely divided materials such as fibers or powders. As (CONTINUED ON PAGE 105)



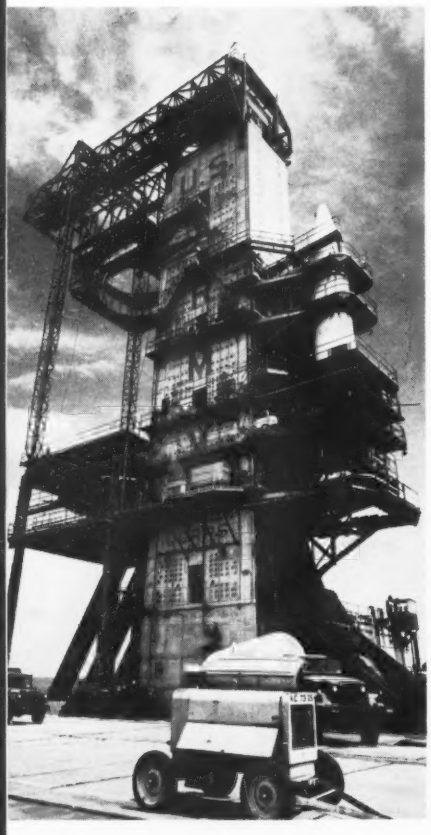
THERMAL PROTECTION SYSTEM FOR SPACE VEHICLE



Far left, an artist's brush adding Saturn booster and thundering exhaust gives this preview of the first static-firing of the eight-engine 1.5-million-lb-thrust rocket. Left, actual booster is placed in its giant test stand.

Saturn—On the mark

The multi-engine, 1.5-million-lb-thrust booster, a future bid for U.S. space supremacy, moves to the testing stand



VIEWING the massive 175-ft-high static-testing tower at ABMA three years ago, you might have wondered—Why so big?— as it was then the test bed for the Redstone and Jupiter missile boosters. The photo far left above, aided by an artist's brush, answers this question. It depicts the eight-engine, 1.5-million-lb-thrust Saturn booster—hopefully the first rocket of its class—roaring through a static-firing on the stand.

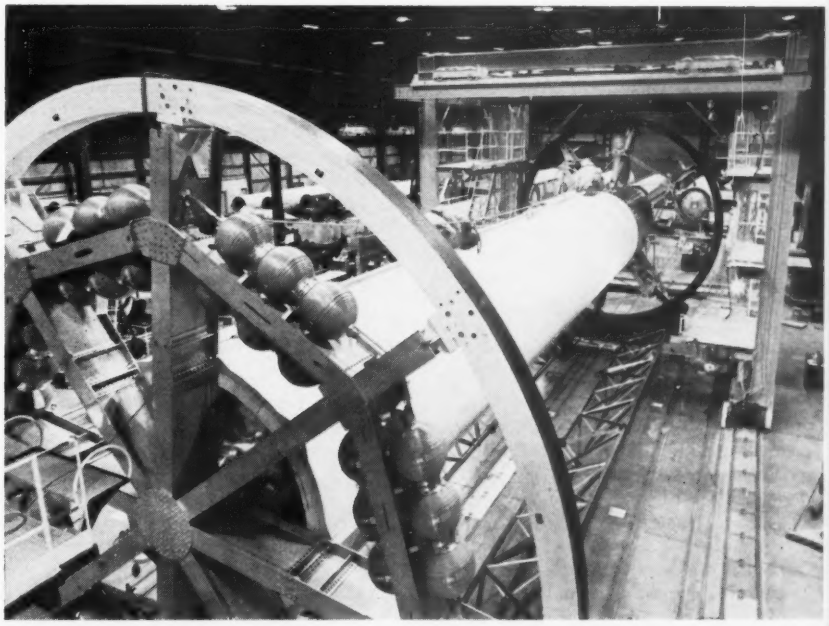
Two month's ago, modification of the stand to accommodate Saturn was completed and the first booster was fabricated. Pictures on these pages show the giant pair in preparation for a history-making first firing.

As widely reported, the Saturn project now moves along at top speed under the impetus of Presidential authorization of overtime and additional funds early in the year. According to Wernher Von Braun, who heads the project for NASA, as he did for the Army, Saturn will be able to put some 12 tons in orbit by 1964, making use of the Centaur engine in upper stages, and almost 25 tons in orbit and manned vehicles in circumlunar flight as soon thereafter as the 200,000-lb-thrust hydrogen-lox engine becomes available.

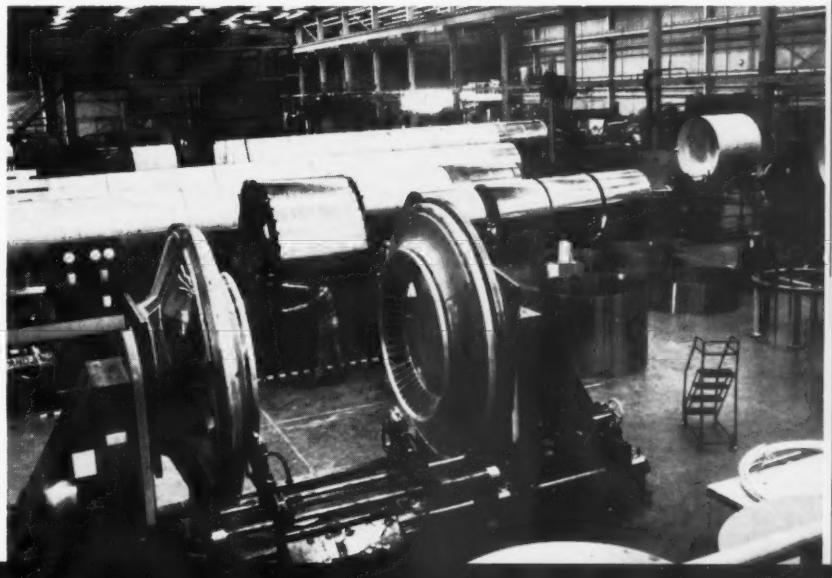
Riding with one of the strongest engineering development groups in the world, the Saturn project thus bids fair to give the Russians a run for the space money if they have failed to amplify the propulsion program that made the Sputniks and Luniks. ♦♦

This massive tower at the ABMA Test Laboratory, previously the stand for Redstone and Jupiter missile development (Jupiter in its cradle at right), was modified to handle the Saturn booster by adding the bridge at top, which carries a 100-ton crane for lifting the booster into position, and huge restraining rings and thrust jack. Also included in the construction operation were underground tanks with piping for emergency dumping of propellants and a million-gallon steel reservoir to supplement the available water supply.

In foreground, engineers check the alignment of the 22-ft-diam booster assembly. Saturn complete with upper stages will stand about 200 ft high.



Shown during assembly, the booster already has its terminal spider rings joined by the central, 105-in.-diam lox tank and will soon have added the eight peripheral, 70-in.-diam lox and kerosene tanks. The linked spheres riding in the near spider carry high-pressure gas for the flight system.



Sections of the booster's tanks sit in various stages of assembly in the Structures Laboratory. The tanks are made chiefly of a high-strength weldable aluminum alloy (5456) developed by Alcoa.

Plasma-Jet Facility for Princeton

Irvin Glassman of Princeton Univ.; B. Redmon, director of research, Air Reduction Co.; C. D. Perkins, chairman of the Dept. of Aeronautical Engineering at Princeton; and S. Marshall, director of metallurgical research at Airco, examine part of the plasma-jet facility recently presented by Airco to the Princeton Aeronautical Engineering Dept. The equipment will be used for instructional and research purposes. Airco is also providing funds for a fellowship in aerothermochemistry to be awarded annually to a Princeton graduate student in aeronautical engineering.

One-O'Clock Propulsion

(CONTINUED FROM PAGE 25)

therefore it is legitimate to use the weight of the object as a measure of the quantity of matter. Yes, just as legitimate as using temperature as a measure of heat! We measure change of heat content by change in temperature and the change in temperature *is* a measure of the change in heat. But let's not express heat in degrees! And let's not use pounds of force per second to express mass flow rate or pounds of force to express the quantity of matter in propellant tanks.

Without worrying about systems of units for now (a less serious problem than the confusion of weight and mass), let's look at a logical definition of specific impulse or specific thrust. Impulse is a physical quantity equal to the product of force and time. Specific impulse is the impulse per unit mass. If we happen to pick English gravitational units, then specific impulse will be in pound-seconds per slug. Since a slug is 32.2 lb, the specific impulse of a propellant combination as defined here would be numerically larger than the common value by a factor of 32.2 and would be numerically equivalent to effective exhaust velocity. Dimensional analysis of the expression pound-seconds per slug will show that this reduces to feet per second.

So specific impulse (or specific thrust) is not just some parameter which is proportional to effective exhaust velocity; it is dimensionally and numerically equivalent, the same thing! Specific impulse, of course, is *not* a measure of time in any sense of the word. It is not a measure of some complex and nonunderstandable ratio of units—it is a measure of velocity.

This is not just a matter of definitions. There is no way that you can define your terms to make a "force flow rate" meaningful except to define force as a measure of quantity of matter. Then what do you call thrust? If you still call that a force, you are using the same word to mean two different things in the same equation. That is not a question of definitions, it is a question of elementary logic.

But, if we use the EGS units, all of our numerical values of specific impulse will change by a factor of 32.2. Well, many of us are already familiar with the corresponding values of effective exhaust velocity, so we would hardly notice the difference.

There is a way, however, to save the present numerical values if we think it is really necessary.

If we define specific impulse in terms of the units—pounds (force) seconds per pound (mass)—as many authors already do, we can keep the present numerical values. If we analyze these units, we find that they reduce to units of velocity. However, the unit of length involved is not the foot, but something equal to 32.2 ft. If we call this unit a stapp (for the fastest man on earth), we find that the vacuum specific impulse of lox + RP1 is approximately 310 stapps per sec.

Of course, this approach to the problem is based on the bastard English system of units, and the high priests of physics may object to such immorality. However, it is logically consistent and reasonably safe if we keep our wits about us, and remember that specific impulse and exhaust velocity are simply different ways of looking at the same physical entity.

Maybe this doesn't seem very important. But what about our kids in school? Should they waste hours of valuable time trying to make sense out of "one-o'clock propulsion systems" which they know *must* make sense because authorities say they do?

Let us get with the weight and mass business before we have our noses rubbed in it out in space.

References

"Principles of Guided Missile Design—Dictionary of Guided Missiles and Space Flight," Edited by A. G. Merrill, D. Van Nostrand, 1959, p. 578.

Sutton, G. P., "Rocket Propulsion Elements," John Wiley & Sons, 1949, p. 19. The second edition backs into a more adequate explanation by way of a footnote on p. 20.

Zaehringer, A. J., "Solid Propellant Rockets," American Rocket Co., 1955, p. 37.

Zucrow, M. J., "Aircraft and Missile Propulsion, vol. 1," John Wiley & Sons, 1958, p. 129. ♦♦

WADD to Hold Space Medicine Meeting in Dayton April 28–29

A two-day symposium, sponsored by the Wright Air Development Division, Wright-Patterson AFB, on the subject of closed-circuit respiratory systems will be held in Dayton, Ohio, April 28–29. Col. John P. Stapp, chief of WADD's Aerospace Medical Laboratory, and 1959 ARS national president, is chairman of the symposium.

Those interested in attending the meeting should contact Allan B. Schwartz at WADD, attention WCLDAE.

Pyroceram Patented

S. Donald Stookey, manager of the Fundamental Chemical Research Dept. of Corning Glass Works, has been issued the first patent for invention of Pyroceram materials.

Kodak reports on:

... sunshine for the plastics man who worries ... a little literature before the 11 o'clock news

Infrared detectors for sale

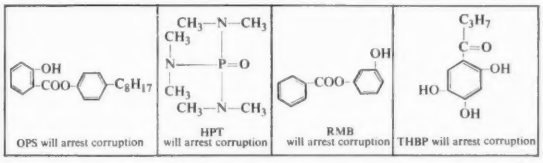
Our involvement in infrared detectors has deepened.

Pictured at the top of this page are, respectively, the simplest kind of *Kodak Ektron Detector* with a rectangular sensitive area of any reasonable dimensions, available either in a 3-pin miniature cable socket or unmounted with resolderable leads; an "immersed" detector with detecting substance deposited on the plano surface of a radiation-collecting lens; a detector mounted in a Dewar for cooling by cryostat. We also deposit detecting substance in separated or intricate configurations as ingenuity, under necessity's goad, may provide.

Since any of these physical forms can now be provided with any of six different kinds of lead sulfide or lead selenide depositions, as governed by spectral sensitivity, response time, temperature, and ambient humidity, the print gets quite fine in a folder we are publishing this month to guide the selection of *Kodak Ektron Detectors.*

A free copy is available from Eastman Kodak Company, Apparatus and Optical Division, Rochester 4, N. Y. It is designed to make the sale with minimum further correspondence. To give you an idea, the off-the-shelf, one-only price scale starts from $14.50.

Corruption can be arrested



"You" are assumed to be a producer of compounds for molding or extrusion. This message is strictly private between you and us. As far as your customers, the molders and extruders, will ever know, the reason why your vinyls, cellulosics, polyesters, or polyolefins stand up so well to weathering is the integrity of your name. And as far as *their* customers will ever know, it is *their* integrity that explains why so little cracking, crazing, embrittlement, gumming, or discoloration with the passage of time and sunshine.

The concept of integrity is more readily grasped than is the principle that every C-C bond, every O-H bond, every C-Cl bond, every C=N bond, has its own price—a photon of ultraviolet radiation just right in energy to snap it. Thus corruption of plastics, a chain reaction like other corruptions, begins. A rival substance that grabs off the u-v photons first and degrades their energy will delay the corruption for a long time.

Other corruptions, initiated by atmospheric oxygen, can be delayed by compounds that stop the action by supplying hydrogen at a critical juncture. Of course, choice in inhibitors is greatly restricted by many considerations of physical and chemical compatibility.

Obviously, we think we have made a good choice in these new ones:

Eastman Inhibitor OPS (p-Octylphenyl Salicylate), at 1 to 5% levels, a preventive of the photo-oxidation that forms deleterious carbonyl groups in polyethylene and polypropylene.

Eastman Inhibitor HPT (Hexamethylphosphoric Triamide), very pale, water-soluble, a liquid u-v inhibitor for use with a heat stabilizer in poly(vinyl chloride) at 1 to 2%.

Eastman Inhibitor RMB (Resorcinol Monobenzoate), a non-coloring u-v inhibitor at 1% levels for transparent cellulose acetate butyrate. Superior to phenyl salicylate. Also protects cellulose acetate, cellulose acetate propionate, polystyrene, poly(vinyl chloride), and ethylcellulose.

Eastman Inhibitor THBP (2,4,5-Trihydroxybutyrophenone), an antioxidant for polyolefins and various paraffin waxes. May be added in solid form directly during the milling process, or in solvent solutions to dry powders or melts, at 0.01 to 0.1% concentrations. Especially valuable for absence of stain at the low concentrations.

Isn't it fun how in the chemical industry practically everybody is simultaneously practically everybody else's customer, supplier, and competitor! Data sheets and development samples (for those in a position to evaluate them) from Eastman Chemical Products, Inc., Kingsport, Tenn. (Subsidiary of Eastman Kodak Company).

Metallography and other matters

You would think we had nothing better to do than write letters and be friendly, helpful, and cheerful.

Though this policy hasn't sunk us yet, we do go through motions to put the dispensing of technical photographic wisdom on a slightly self-sustaining basis. For those who have not yet delved deep enough to frame specific questions, we publish what we call *Kodak Data Books* and print on the cover a small cash price, like 50¢.

Just issued is a new one, "Photomicrography of Metals." It contains 13 pages on the metallographic microscope (unbiased toward any particular make of instrument, since we are not in that business), 3 pages on illumination, 5 on filters, 3 on photographic materials (which we do make), 5 on exposure determination, and 8 on processing and printing—just enough for thoughtful perusal between the evening paper and the 11 o'clock news. The pages are meaty; the illustrations are there to explain, not just fill space; the author (anonymous) is a photomicrographer, not an ad-writing hack.

Also just published is the 8th edition of one that has taught many thousands of people since 1933 the rock-bottom facts about the photographic emulsion as a scientific device. The title, "Kodak Photographic Films & Plates for Scientific and Technical Use," dissembles a wee bit. In the old days astronomy was regarded as too thin and unworldly a market to justify commercial literature; therefore the title was devised as a shield from the beady eyes of hard-headed accountants. They find it hard to understand that addressing ourselves to the needs of men with their minds inside stars strengthens the capabilities of photographic technology in general. Indeed, this new 8th edition contains some helpful hints from Mount Wilson and Palomar Observatories that could teach an amateur astronomer to think like a pro. The edition reveals some constriction from the sprawling diversity of *Kodak "Spectroscopic" Plates and Films* hitherto offered, and these pages show how the present lineup fills the bill.

Theoretically the purchase of these data books from your Kodak dealer draws him and you closer together. Those willing to forego the personal touch can obtain them from Special Sensitized Products Division, Eastman Kodak Company, Rochester 4, N. Y., which is also the place to address specific questions.

Price quoted is subject to change without notice.

Kodak
TRADE MARK

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

In print

Handbook for Space Travelers by Walter B. Hendrickson Jr., Bobbs Merrill, Indianapolis, 1959, 256 pp., illustrated. $3.95.

First into Outer Space by Theodore J. Gordon and Julian Scheer, St. Martin's Press, New York, 1959, 197 pp., illustrated. $3.95.

Atlas, The Story of a Missile by John L. Chapman, Harper & Bros., New York, 1960, 190 pp., illustrated. $4.

It is entirely conceivable that, by the end of this year, every possible type of book about rocketry and astronautics will have been published—and not once, but several times. The spaceflight field has proved to be of such interest to the publishing fraternity that almost anything anyone writes eventually finds its way into print. Just how many copies of these books are actually sold is a matter of interest primarily to the publishers (and, one supposes, to the authors), but no matter how small the sales may be, the books continue to roll off the presses at better than a five-per-month rate. (In fact, things have gotten so bad that you can now join an "Aerospace Book Club" if you so choose.)

These three books might be described, in order, as being of the "what it's all about," "how we did it," and "what a space vehicle is" variety, which just about covers the field. Oddly enough, standardization in the publishing of books about space and rockets has reached the point where even the prices come out within a few cents of each other.

"Handbook for Space Travelers" is a typical what-it's-all-about type of book for youngsters, better than some, not as good as others. Designed, according to the author's introduction for "you, the future space traveler," it attempts to do what Willy Ley, Carsbie Adams, and a score of others have already done elsewhere at a slightly higher technical level. It is difficult to judge just what the audience for a book of this kind would be. Certainly it would seem that any youngster with a real interest in the subject is already past the point where a book of this type would offer any great attraction.

"First into Outer Space," the how-we-did-it volume, is the blow-by-blow account of the launching of the U.S. Pioneer II 70,000 miles into space, written by Ted Gordon, a Douglas engineer who acted as test conductor for the three AF lunar probe attempts, plus one ghost. Embellished with some previously unpublished photos and sketches, the book provides a graphic account of the launching through the eyes of one engineer who participated in it; but, viewed in the light of what has already transpired since that day in October 1958, it already has the faint aura of past history, interesting but hardly of major significance. Authors in this field unfortunately learn all too quickly that history is moving entirely too fast in the field of astronautics to make publication of books of this type a major landmark.

In "Atlas," the author, on the editorial staff of Convair-Astronautics, has the advantage of telling a story the beginning of which, at least, is little known to the American public. The result is that the early chapters, tracing the history of the first U.S. ICBM back to its beginnings in Convair's (and Charlie Bossart's) little-heralded but extremely important Project MX-774, which led to development of the Atlas, make for fascinating reading.

Even after Chapman gets past this point, the book retains its interest, although some subjects, such as the Cape Canaveral complex, have been covered far better elsewhere. Nonetheless, good writing, and an obvious familiarity with the subject under discussion, make for an interesting and enlightening book—always assuming, of course, that the reader has as much interest in Atlas as the author obviously does.

Some excellent photos contribute greatly, and a page of candid shots of Krafft Ehricke is in itself almost worth the price of the book.

—Irwin Hersey

BOOK NOTE

In the midst of ever-increasing speculation on whether or not intelligent life exists on other planets, *New Yorker* cartoonist Alan Dunn has created a fascinating word-and-picture story entitled **"Is There Intelligent Life on Earth?"** (Simon & Schuster, $3.50). The answer to this rather startling question is given in the form of a report written by a trio of Martian Senators who have come to earth to ascertain whether certain UFO's sighted in the skies of Mars "were imaginary on the part of the observer or possibly represented the existence of intelligent life on one of the inner planets." They never do answer the question posed by the book's title, but their encounters with such interesting earth phenomena as Coca Cola and the law of supply and demand make for an entrancing book, and one that should delight anyone with an interest in astronautics.

—I.H.

RECEIVED

Annals of the International Geophysical Year: Vol. 1—The Histories of the International Polar Years and the Inception and Development of the International Geophysical Year (466 pp., Pergamon Press, New York, $17). Paperbound.

IXth International Astronautical Congress, Amsterdam, 1958: Proceedings, Vols. 1 and 2 (970 pp., Springer-Verlag, Vienna).

A Space Bibliography Through 1958 by Raymond Estep (109 pp., Air Univ., Maxwell AFB, Ala.). Paperbound.

Index of NASA Technical Publications (166 pp., NASA, Washington, D.C.). Paperbound.

The First Decade of the International Astronautical Federation by F. C. Durant III (64 pp., Avco Corp., Wilmington, Mass.). Paperbound.

Scientific Information Activities of Federal Agencies (No. 3), National Science Foundation (23 pp., Government Printing Office, Washington, D.C. 15 cents). Paperbound.

Federal Funds for Science: VIII. The Federal Research and Development Budget, Fiscal Years 1958, 1959, and 1960, National Science Foundation (74 pp., Government Printing Office, 45 cents). Paperbound.

Aircraft & Missiles by Dennis M. Desoutter (213 pp., John de Graff, New York. $7.50).

The Planet Venus by Patrick Moore (151 pp., Macmillan, New York, $3.75).

Conquest of the Air by Hendrik de Leeuw (300 pp., Vantage Press, New York, $4.95).

X-15, Man's First Flight into Space by Martin Caidin (64 pp., Ridge Press, 551 Fifth Ave., New York 17, 25 cents). Paperbound.

Seeing the Earth from Space by Irving Adler (160 pp., John Day, New York, $3.50). Early high-school level.

Moon Base by William Nephew and Michael Chester (72 pp., Putnam, New York. $2.75). Kids.

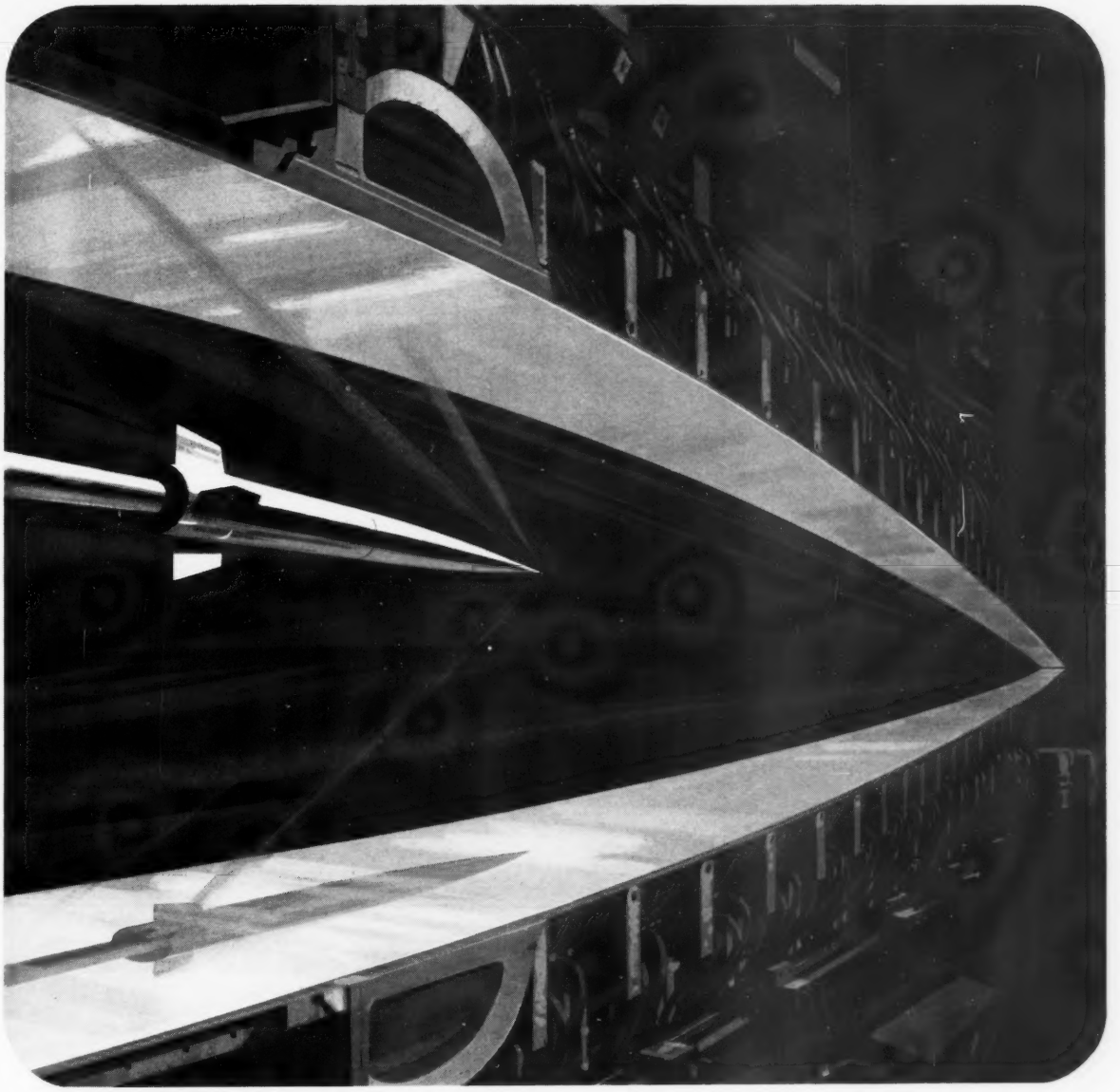
Our Space Age Jets by C. B. Colby (48 pp., Coward-McCann, New York, $2). Kids.

German Secret Weapons of World War II by Rudolf Lusar (265 pp., Philosophical Library, New York, $10).

Science and Technology in Contemporary War by G.I. Pokrovsky (180 pp., Praeger, New York, $4). Russian translation.

Engineering College Research Review, 1959, edited by Renato Contini and Paul T. Bryant (445 pp., Engineering College Research Council of the American Society for Engineering Education, Univ. of Illinois, Urbana, Ill., $2). Paperbound. ◆◆

NOTABLE DEVELOPMENTS AT JPL



HYPERSONIC WIND TUNNEL

One of the latest research facilities at the Jet Propulsion Laboratory is the recently completed, continuous-flow hypersonic wind tunnel. Developed by the Lab, this new tunnel generates air speeds up to ten times the speed of sound. Its 21-inch square test section provides accommodation for models up to four feet long thus permitting increased model instrumentation. This large test section at Mach 10 with a continuous uniform air flow broadens JPL capabilities in the important area of fluid dynamic research.

To minimize structural deflections due to temperature changes and thus the time required to reach equilibrium conditions, the entire tunnel structure is water cooled and housed in an air conditioned building. Any Mach number between five and ten can be precisely set by means of flexible stainless steel nozzle plates that are positioned to a ten-thousandth of an inch. Calibration results indicated satisfactory solution of the design problems encountered.

The high speed data-acquisition, reduction, and presentation system is designed for high production testing of the nation's most advanced missiles and re-entry configurations. Stability and control phenomena in new regimes can be studied experimentally under carefully controlled conditions.

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Missile market

By Jerome M. Pustilnik, Financial Editor

Guest columnist Fred Stein, ARS member, security analyst, and member of the research staff of Argus Research Corp., in discussing Philco Corp. fulfills the commitment made in last month's column.

IN TODAY'S inflated electronics market, Philco Corp. seems speculatively attractive. Philco is basically two different companies: One heavily involved in the appliance business, the other actively participating in defense and industrial electronics. The industrial and defense electronics activity is divided roughly into five different groups (1) communications, (2) tubes and semiconductors, (3) radar systems, (4) space technology and guided missiles, and (5) computers, with semiconductor operations the most dynamic area. The overwhelming majority of Philco's production is concentrated in the industrial and military.

In the semiconductor field, Philco developed its own basic design, the chemical-etch transistor. And today the company has about 50 patents protecting two basic processes—the electrochemical etch and the alloy junction. Another extremely important development—producing royalties—is the new Fast Automatic Transfer (FAT) lines, combining previously separate operations into one continuous production line, turning out high-power, fast-switching type transistors.

During the current year, Philco's semiconductor volume, almost entirely of these better-quality transistors, will amount to some $50 million compared with between $22 to $25 million in 1959. At this volume, and using an extremely conservative profit margin for this industry, semiconductor operations could contribute $1.00 per share to Philco earnings. Philco also produces vacuum and cathode ray tubes. Total tube volume during 1959 was between $18 to 20 million, with no appreciable increase likely for 1960.

The company has participated in the Sidewinder, Corporal, Talos, Little John, Falcon, Tartar, and Terrier programs. It has developed the communications systems for the Discoverer and Sentry, and produced telemetry systems, transmitters, receivers, converters, and antennas. Philco is currently participating in Aircom; voice, facsimile, and other communications media. Since early 1950, Philco has lagged in radar, but recently began to make inroads into this large-volume field.

Regarding the Transac-2000 and other computers in the Philco line, it is likely profits from this area are still a few years away. Past writeoffs like those of 1958–59 will not be duplicated in 1960, but some drag on earnings from these products may continue.

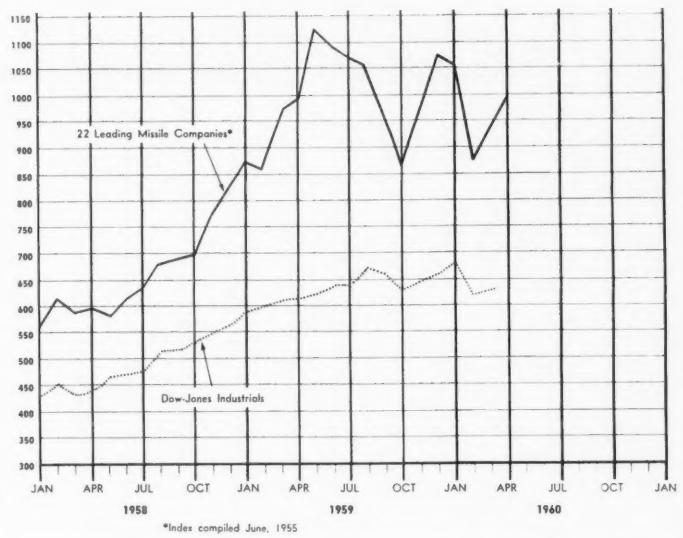
All in all, therefore, nonappliance business will account for approximately $180 million of Philco revenues during 1960, a substantial increase from the estimated $135 million recorded in 1959. Gains in defense and industrial electronics should more than offset any dips in the appliance cycle that may develop over the next few years, bulwarking Philco's future growth.

Appliance sales accounted for about $260 million in 1959, and is expected to remain approximately the same in 1960. Philco, which at one time was a leading factor in the sale of white goods and radio and television sets, has moved to a secondary position in recent years. In a 1958 managerial reorganization, the company attempted to take steps to offset the cyclical nature of appliance business. Hence the only reservation in this evaluation of Philco is in regard to this segment of the company's activities.

During 1959, Philco reported sales of about $400 million and per share earnings of $1.67. For the current year, Philco may report sales of $450–460 million and could earn as much as $3.00 to $3.25 per share. However, in view of recent softness in appliances and the probable disruption of production schedules, this projection could be tempered to the more conservative estimate of between $2.50 to 2.75 a share.

Philco's capitalization contains $45.5 million of long-term debt (including $22 million of debentures convertible into common stock at $33.33 per share until 4/15/69, and then higher); 100,000 shares of $3.75 cumulative preferred stock; and 4,074,866 shares of common stock. All these securities are listed on the New York Stock Exchange. ♦♦

THE MARKET AT A GLANCE



*Index compiled June, 1955

	March 1960	February 1960	% Change	March 1959	% Change
Dow-Jones Industrials	630	623	+1.1	603	+4.5
Missile Index	993	875	+13.4	972	+2.2

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☐ GUIDANCE DEVICES ☐ INFRARED ☐ INERTIAL GUIDANCE ☐ _____
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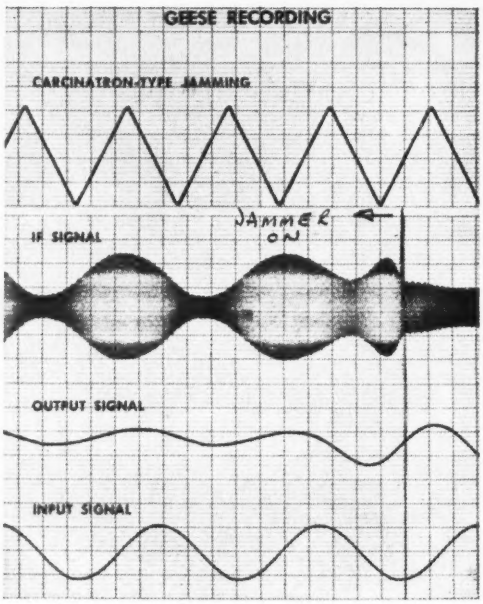


EVOLVING LARGE-SCALE SYSTEMS CONCEPTS

AND DEVELOPING THE TOOLS THAT SPEED THEIR DESIGN CYCLE

Defense Systems Department is directing its technical capabilities toward the development of large-scale electronic systems. Inherent within this work program is the recognition, definition and solution of problems in every aspect of the systems technology.

To accomplish this ambitious task, a growing number of studies are being directed toward the development of unique tools that will aid in the design of superior systems in less time, at lower cost.

A recent contribution by Defense Systems Department in this technological area is GEESE (General Electric's Electronic System Evaluator). Utilizing advance computer techniques, it enables systems engineers to accurately predict, optimize and synthesize system performance prior to design.

GEESE is indicative of the scope of Defense Systems Department's involvement in the systems technology. Many programs offer systems-oriented engineers and scientists an opportunity to participate in new areas of long-term importance.

Senior members of our technical staff would welcome the occasion to discuss personally and in detail the career positions available with this growing organization. Address your inquiries in professional confidence to Mr. E. A. Smith, Box 4-A.

DSD DEFENSE SYSTEMS DEPARTMENT
A Department of the Defense Electronics Division

GENERAL ELECTRIC

Northern Lights Office Building, Syracuse, New York

Extraterrestrial Life

(CONTINUED FROM PAGE 33)

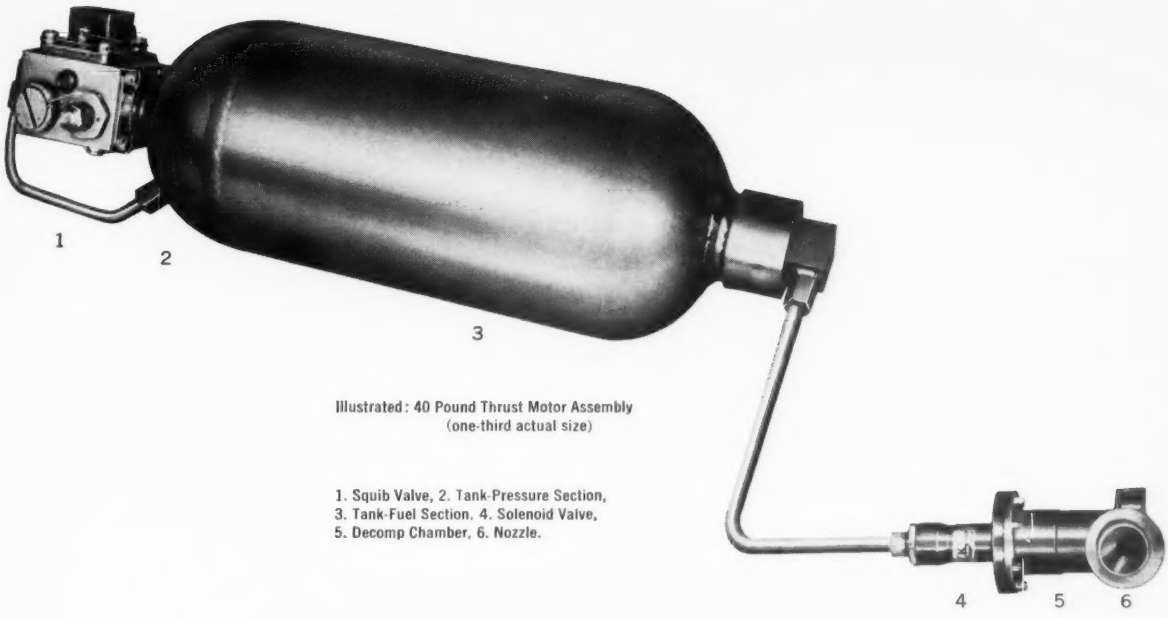
past generation have given strength to our belief in extraterrestrial life.

The region in a planetary system where water, the effective solvent, can exist in a liquid state, we shall call the liquid-water belt. The planets Venus, Earth, and Mars lie in this interval of distance from the sun; and, of course, in that belt some of the little asteroids move, but they can well be forgotten because their small masses hold no atmospheres and thus deny existence to anything that breathes. Mars is near the outer limit of the belt, Venus rather near the inner limit. If our sun were brighter, the belt would lie further out; if fainter, the belt would be nearer the sun.

To begin with, let's consider the earth only. From the early times of its separate existence, it naturally has had an atmosphere. The present character of surface rocks and of other factors has led scientists in several fields to believe that the primitive atmosphere was essentially without free oxygen. It was a "reducing" atmosphere, dominated by hydrogen. In fact, it is consistent with our knowledge of present planetary atmospheres to hold that the elements hydrogen, carbon, nitrogen, and oxygen (the chief constituents of protoplasm) were present and dominant in the primitive terrestrial atmosphere. These four elements would appear in the form of methane, ammonia, water vapor, and hydrogen. With such an atmosphere, in turbulent motion of course, electrical action would be inevitable. Therefore the energy of lightning and the proper chemical constituents would both have been available billions of years ago for nature's synthesis of the amino acids. And, since the available times are so long that even improbable events become inevitable, the building of proteins out of amino acids would also be a natural operation.

The steps in the natural building up, from the simpler proteins, of those macromolecules whose habit of self-replication means life, are readily visualized. This bridging, by natural operations, of the gap between the lifeless and the living has in the past few years been taken up so vigorously by the microbiologists and biochemists, with the assistance of virologists, and has been pursued with so much success, that the production of "test-tube life" is no longer considered impossible.

These new discoveries, which indicate that life can begin, struggle with



Illustrated: 40 Pound Thrust Motor Assembly
(one-third actual size)

1. Squib Valve, 2. Tank-Pressure Section,
3. Tank-Fuel Section, 4. Solenoid Valve,
5. Decomp Chamber, 6. Nozzle.

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the environments, and in some cases persist if the chemistry, physics, astronomy, and climates are right, have changed the picture of habitability. Life must exist nearly everywhere, if planets are everywhere. (Close double stars, however, which are very common, are hostile to stable watery climates, and therefore to life. They do not tolerate, under gravitational laws, planetary orbits that would be suitable for the existence of liquid water.)

Are We Unique?

Since life can be a natural evolutionary product on certain planets, the next question therefore concerns the frequency of such suitable planets. If we had strong arguments against the birth and continuity of planets, we might make the comforting inference that perhaps we are unique in the universe—that life is found only here, on this small planet that circles a star of a very common variety, located out toward the edge of an average large galaxy containing billions of other suns, and this galaxy but one of billions in the universe we know. The evidence is quite the contrary. There is no likelihood that we are unique, no indication that other planets are nonexistent or even scarce.

The discovery of the expanding universe, established through the evidence of the present scattering of the billion-starred galaxies, carries with it the indication that some thousands of millions of years ago (perhaps 10^{10} years) the $> 10^{12}$ galaxies, and probably all other matter of the recognized universe, were closely compressed into small volume (perhaps into the speculative primeval supergiant atom of Lemaître). At such a time of dense population, disruptive processes such as collisions could produce the materials of stars and planets. Also, several thousand million years ago the oldest rocks on the earth's surface came into existence.

The important conclusion is that the earth was born in those turbulent, crowded times at or near the beginning of galaxy scattering. Naturally other planetary systems would also date from then. Our sampling tells us there are literally trillions of stars just like our sun—like it in color, mass, size, temperature, mean density, and other essential properties. Thousands are in our immediate neighborhood, out here toward the local edge of our spiral galaxy. They too must have had the experiences that produce planets.

When we add to these considerations the calculation that the sum total of stars is not less than 10^{20}, and that these stars are all radiating the energy necessary for synthesis of the animate out of the inanimate on whatever planets may be suitably placed, we reach the conclusion that habitable planets must be very abundant. Great numbers must be not only habitable but must have actually experienced the natural evolutionary process that leads to simple living organisms, which, in turn, over the millennia, lead to the more complicated plants and to the more active sentient animals.

In conclusion, we may list the more important conditions necessary for the persistence of protoplasmic life once it is started on a planet that circles a star on which it is dependent for warmth and light:

A reasonably stable star.

A planetary orbit at least roughly circular.

The availability of water (or, *very* unlikely, some other solvent).

A suitable chemical nature (nonpoisonous) of the air, oceans, and soils.

All organisms so conditioned by ignorance or morality that they will not destroy all life, including their own, by poison or planet disruption. (This last condition is now the most important for the *persistence* of life on our own planet.)

A few comments are offered on these requirements for continued habitability. The star must not be too irregular in its output of radiation; otherwise, it would freeze out life or incinerate it. Supernovae (exploding stars) would be lethal to protoplasm.

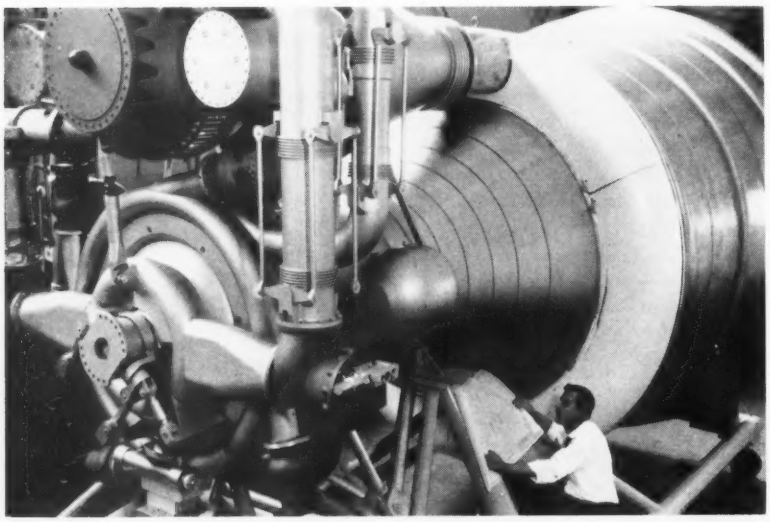
If life through natural or human mishap is once cleared off a planet completely, it might not start again. Our free-oxygen atmosphere, which photosynthesis began to provide as soon as chlorophyll plants appeared, would probably dispose of any macromolecules that aspire to self-replication.

A considerable diversity in the abundances of the various chemical elements could be tolerated *if* the planetary life grew up under those diverse conditions.

Man's Inhumanity to Man

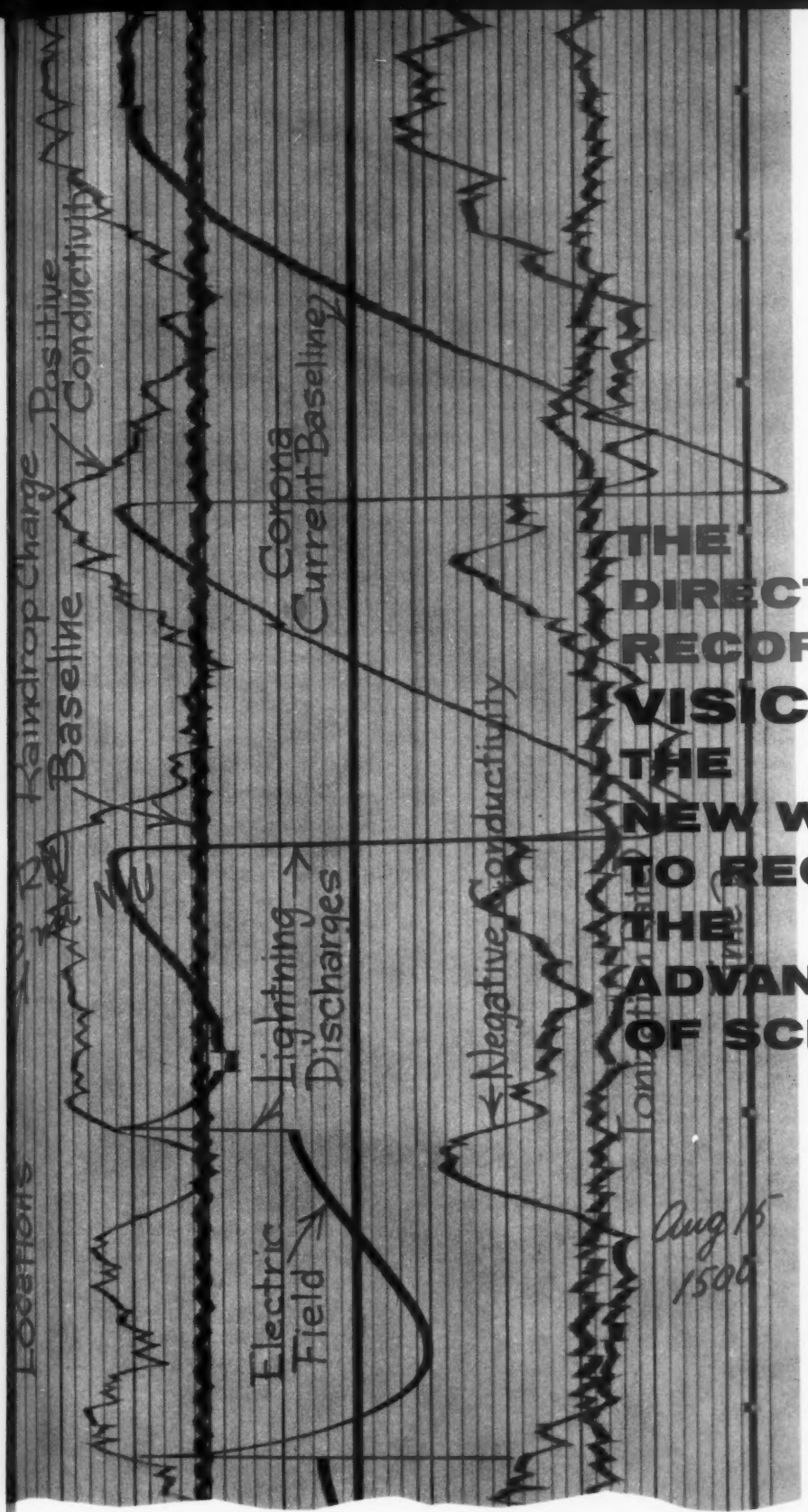
Also, much diversity could be allowed in the temperature, the shape of the planet's orbit, and in its rotation and revolution periods, if proper vital adjustments were made to meet prevailing conditions. We have in the past billion years survived easily much mountain building, wide dessications, flooding, and advancing ice sheets. In the future we can face calmly the environmental changes produced by the sun, the earth, the atmosphere, and the lower forms of life.

But can we survive the hazards created by "humanity?" It may be that the continued habitability of this, our planet home, is man's greatest problem. ♦♦



Wow!

A full-scale mockup of the million-lb-thrust F-1 (Nova) engine under development by Rocketdyne for NASA deserves an exclamation. Rocketdyne reports good progress on the engine. A full-scale uncooled static-firing engine achieved more than a million-lb thrust with stable combustion last August.



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Honeywell

MODEL 906 VISICORDER

. . . pioneer in the field of Ultra-Violet direct recording

Two models of the 906 Series Visicorder give you a choice of recording capacity on 6″ paper.

The Model 906 B-1 uses high-sensitivity Series M sub-miniature plug-in type galvanometers that are directly interchangeable among all Honeywell oscillographs of the sub-miniature galvanometer type. Optical arms, therefore galvanometer sensitivities, are an identical 11.8 inches in all instruments.

The 906 B-1 provides for 14 channels of recording including two static reference traces —each channel operating at frequencies from DC to 5000 cps. It has provisions for recording intensity control; trace identification; grid line system (either inches or millimeters) and selectable record speeds (a choice of 5 interchangeable systems, each covering 4 speeds).

The Model 906 B-2 is identical to the 906 B-1, except that it uses solid-frame galvanometers with a capacity of 8 channels, including 2 timing or event-marking channels.

Accessories available for both models of the 906 B include a record take-up unit; record takeup and latensifier; relay rack adapters; and the Visicorder Timing Unit.

Honeywell

MODEL 1108 VISICORDER

. . . newest of the Honeywell direct-recording oscillographs

The Model 1108 delivers direct-writing Visicorder oscillography at the lowest cost per channel. Intermediate in size between the 14-channel 906 and the 36-channel 1012, the 1108 simultaneously records up to 24 channels of data on a record 8 inches wide. This instrument, like other Visicorders, records at frequencies from DC to 5000 cps with unparalleled galvanometer sensitivities.

Pushbutton controls give a choice of 15 record speeds from .05 to 80 inches per second, and time line intervals of 1, .1 and .01 seconds. Such built-in features as automatic record length control, grid-line intensity control, galvanometer spot intensity control, record numbering, reversible record drive, trace identification, provision for remote operation, and many others contribute to maximum convenience in recording high-speed analog data.

As in all Honeywell Visicorders, paper loading, access to the interior, and galvanometer adjustment is easy and convenient.

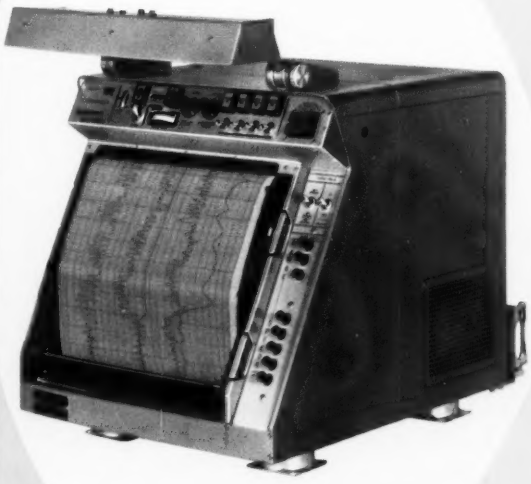
Honeywell

MODEL 1012 VISICORDER

. . . the most complete, convenient multi-channel oscillograph on the market today

The Model 1012 has been accepted as "the most versatile instrument ever devised for converting dynamic data into immediately visible read-out." It will record up to 36 channels of data simultaneously on 12″ wide paper. It gives complete push-button control of 15 different paper speeds, from 0.1 to 160 in./sec., with automatic recording intensity control. Designed into the 1012 are many other convenience features: daylight paper loading; reversible record drive choice; switch selection of 5 different timing intervals (.001 to 10.0 seconds); simultaneous recording of amplitude reference (grid) lines; trace identification; automatic record length control; record numbering; jump-speed control and provisions for remote and/or multiplexed operation.

Like other Visicorders, the 1012 makes use of the sub-miniature galvanometer. All instruments are readily adaptable to rack and shock-mounting.



Honeywell

SIGNAL-CONDITIONING SYSTEMS

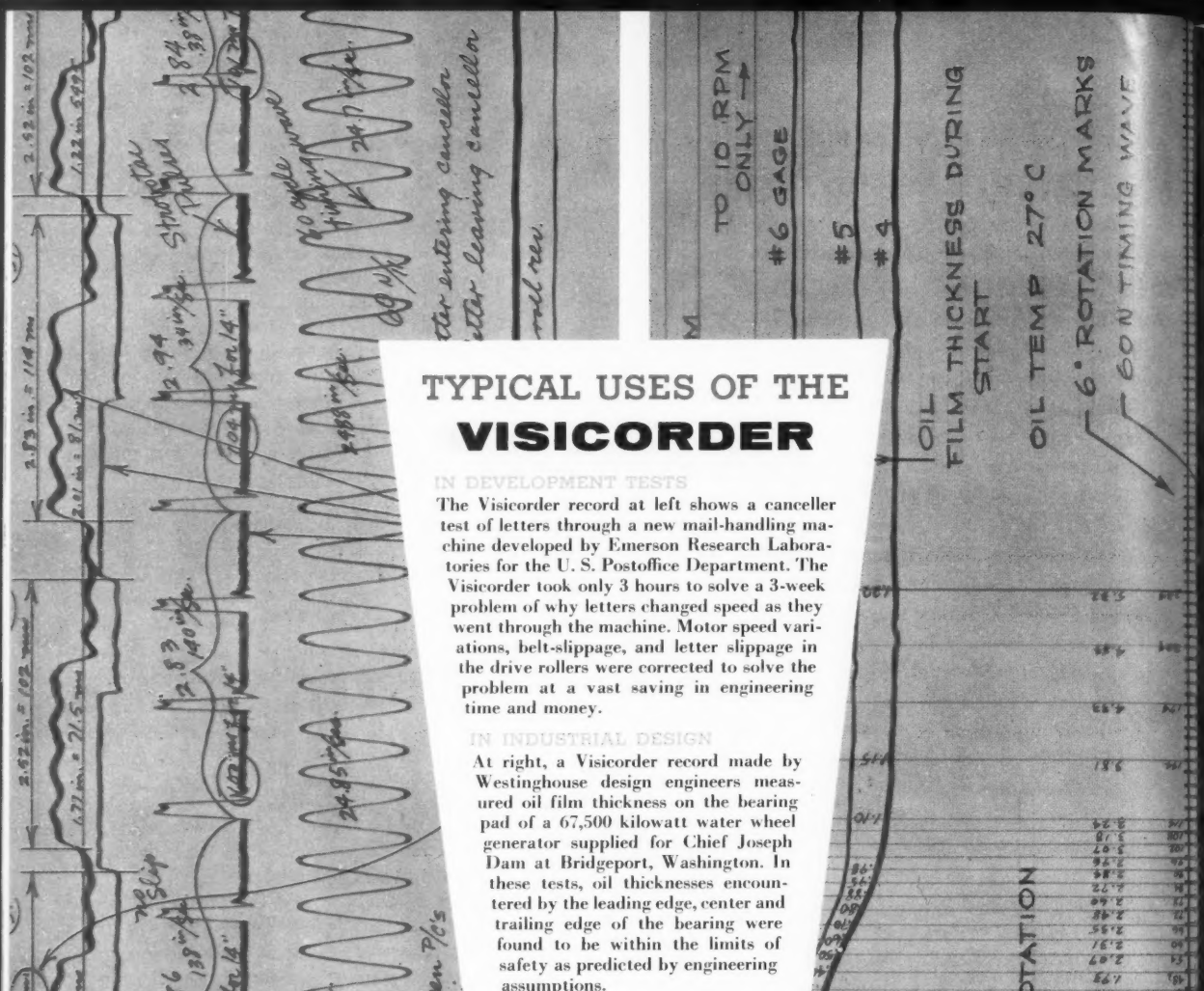
A. The Model 119 Amplifier System . . . a simple and accurate 6-channel carrier amplifier, for use in oscillographic recording, which may be converted to a linear/integrating system simply by installing linear/integrating channels in the same case. The carrier amplifier is designed to amplify signals from resistive, variable-reluctance, differential-transformer, and capacitive transducers. The linear/integrate amplifier is used in conjunction with self-generating transducers such as vibration pickups, etc. The carrier system provides recordings in the 0-1000 cps range at galvanometer amplitudes of 8″ peak-to-peak. The linear-integrate system accommodates frequencies from 5-5000 cps.

B. The Model 130-2C Carrier Amplifier . . . a two-channel unit for use with resistance, reluctance, differential transformer, and capacitive transducers. Produces 8-inch (peak-to-peak) galvanometer deflections up to 1000 cps from as little as 0.5 mv gage output.

C. The Model 82-6 Bridge Balance and Strain Indicator . . . a simple, accurate 6-channel unit for calibrating, balancing, controlling, and measuring static and dynamic phenomena from resistive transducers.

All three of these units are suitable for convenient rack mounting.

FROM HONEYWELL A DIAMOND JUBILEE PARADE OF PRODUCTS



TYPICAL USES OF THE VISICORDER

IN DEVELOPMENT TESTS

The Visicorder record at left shows a canceller test of letters through a new mail-handling machine developed by Emerson Research Laboratories for the U. S. Postoffice Department. The Visicorder took only 3 hours to solve a 3-week problem of why letters changed speed as they went through the machine. Motor speed variations, belt-slippage, and letter slippage in the drive rollers were corrected to solve the problem at a vast saving in engineering time and money.

IN INDUSTRIAL DESIGN

At right, a Visicorder record made by Westinghouse design engineers measured oil film thickness on the bearing pad of a 67,500 kilowatt water wheel generator supplied for Chief Joseph Dam at Bridgeport, Washington. In these tests, oil thicknesses encountered by the leading edge, center and trailing edge of the bearing were found to be within the limits of safety as predicted by engineering assumptions.

OTHER USES of the Visicorder . . . as a direct readout unit **IN RECORDING AND MONITORING SYSTEMS . . . IN MISSILE AND ENGINE ANALYSIS** for test stand recording . . . for analog recording **OF TELEMETERED SIGNALS . . . IN CONTROL** to monitor reference and error signals . . . **IN NUCLEAR TEST** to record temperatures, pressures, impacts, etc. . . . **IN LABORATORIES** for all-purpose analysis . . . **IN PRODUCTION** for final dynamic inspection . . . **IN COMPUTING** for immediately-readable analog records . . . **IN PILOT COMPONENT TESTS** for rapid evaluation of prototypes . . . **IN ALL TESTS** which are non-repetitive in sequence, making oscilloscopes impractical.

Write for your *free* copy of the new 36-page Visicorder Applications Manual, a comprehensive, detailed guidebook to many varied uses of the Visicorder.

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ARS news

Ballistic Missile Defense Conference Draws Attendance of 625

WILLIAMSBURG, VA.—The Ballistic Missile Defense Conference, co-sponsored by ARS and ARPA and held February 17–19 at Phi Beta Kappa Hall on the campus of the College of William and Mary here, drew an attendance of more than 625 scientists and engineers anxious to participate in what amounted to a three-day "brainstorming" session designed to produce some new approaches to the problem of defending this country against enemy ballistic missiles.

The Secret meeting, first all-classified meeting in ARS history, was cosponsored by the Society's Communications, Missiles and Space Vehicles, Ion and Plasma Propulsion, Instrumentation, and Physics of the Atmosphere and Space Committees, in cooperation with ARPA. Program chairman for the conference was W. R. Hutchins of Raytheon's Washington office, who worked closely with William W. (Kip) Edwards of ARPA in planning the conference.

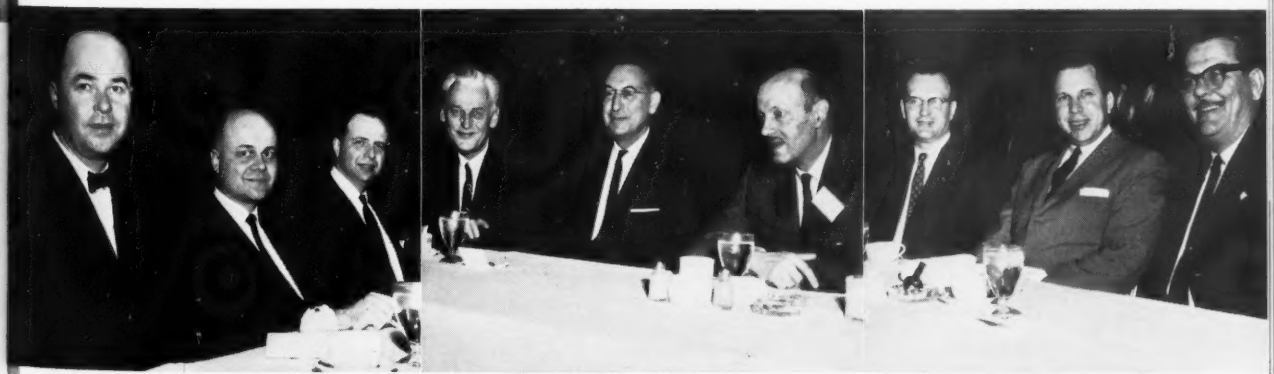
In all, 23 papers were presented at six technical sessions, dealing with the over-all problem, decoy discrimination, current ballistic-missile defense system developments, acquiring information on the problem, physics relating to the problem, and plasma physics as related to the problem. Brig. Gen. A. W. Betts, ARPA director, kicked off the meeting, delivering the keynote address at the opening session.

Hector Skifter, Asst. Director of Defense Research and Engineering (Air Defense), DOD, guest speaker at the Conference, pauses while preparing to make a point.

Featured speaker at the banquet was Hector Skifter, assistant director of Defense Research and Engineering (Air Defense) for the Department of Defense. Banquet toastmaster was Harold N. Beveridge, chief of the Ballistic Missile Defense Branch, Advanced Research Projects Div. of the Institute for Defense Analyses.

In his address, Dr. Skifter noted that there are actually three types of missile defense systems, which are distinct and separate from one another. The first is a system for use in a limited war, which is relatively straightforward and simple. This can be accomplished today from the technical standpoint. The second is a deterrent system, designed to keep any sane enemy from attacking us, and Dr. Skifter believed we have such a system today in our warning system and SAC's B-52 bombers. Our No. 1 job at the moment, he added, is to maintain this deterrent power in such a form that the enemy cannot plan an attack which would destroy the deterrent before it can destroy him. This means developing offensive weaponry, determining how weapons can be employed and dispersed for maximum effectiveness, and making sure our defense is developed to a point where it is difficult for the enemy to plan a sure-fire "win" strategy.

The third type of defense system, he went on, is the system designed to protect the population, and this is a much more difficult problem. Such a system must be good, he pointed out, or all it would mean is that the enemy need use a few more missiles. However, a system of this kind might also be thought of as a deterrent, rather than in terms of protecting a city, and he felt that technology can be brought around to development of a system which would not only contribute to



Head table at the banquet. Left to right, James J. Harford, ARS executive secretary; program chairman W. R. Hutchins of Raytheon; George P. Sutton, ARPA chief scientist; guest speaker Hector Skifter; toastmaster Harold N. Beveridge, chief, Ballistic Missile Defense Branch, Advanced Research Projects Div. of the Institute for Defense Analyses; John M. Ide, assistant director, ARPA's Technical Operations Div.; Maxwell W. Hunter of Douglas, chairman of the ARS Missiles and Space Vehicles Committee; Hugh Sisson, bursar, College of William and Mary; and Maj. John K. Stein (USAF), in charge of security arrangements for the meeting.

our deterrent posture, but might also protect our cities.

Work now going on looks good, he added. A 15-min warning system has already come into being, and he envisioned the possibility of extending this warning period to 30 min. The problem is tough, but not impossible, and valuable bits of information are coming in, even if no complete system is evident as yet.

Security arrangements for the meeting, which meant passing all of the 625 people who attended through clearance lines for each session, were admirably handled by Maj. John K. Stein (USAF) of ARDC and his competent crew. A vote of thanks is also due William E. Bippus of Williamsburg Restoration, Inc., for the admirable arrangements made for housing and transportation of all those who attended the meeting.

—Irwin Hersey

Biggest Ever Semi-Annual Meeting Shaping Up For Los Angeles

The ARS Semi-Annual Meeting, to be held May 9–12 at the Ambassador Hotel in Los Angeles, is shaping up as the biggest in the Society's 30-year history. The program now calls for an all-time Semi-Annual Meeting high of 31 technical sessions (only two of which are classified), four luncheons, a banquet (to be marked this year by special ceremonies in honor of the Society's 30th Anniversary), another in the successful series of marketing symposiums, and, of course, the Astronautical Exposition, long a sellout.

The heavy load of technical papers to be presented has necessitated the scheduling of quadruple sessions on three mornings and two afternoons during the meeting, while two special evening sessions are also planned—one covering "Latest Events in Spaceflight," and similar to the successful session of this type held at the Annual Meeting, and the other on "Liquid vs. Solid Rocket Capabilities," classified Secret.

The sessions will cover almost every facet of propulsion and space technology, ranging from magnetohydrodynamics through education in the Space Age. The second classified (Secret) session will be devoted to "Mobile vs. Hard Base Installations." A rundown on the technical sessions to be held will be found at the bottom of this page.

ARS National President Howard S. Seifert and Bruce Old, vice-president of Arthur D. Little, have already accepted invitations to address luncheons. The banquet speaker and additional luncheon speakers will be announced shortly.

The full program for the meeting will appear in the May issue of *Astronautics*.

Semi-Annual Meeting Committee pose at get-together to make plans. Left to right, seated, John J. Maucieri, arrangements chairman; Tom B. Carvey Jr., general chairman; Mrs. Herbert H. Isaacs, in charge of ladies' events; and Herbert H. Isaacs, publicity chairman. Standing, left to right, C. J. Hamlin, reception chairman, and John G. Kimball, in charge of field trips.

63 Exhibitors Signed Up For Los Angeles Exposition

A total of 63 exhibitors will show their wares at the ARS Astronautical Exposition, to be held, in conjunction with the Semi-Annual Meeting, at the Ambassador Hotel in Los Angeles May 10–12.

The list of exhibitors, along with booth numbers, follows:

Stage, Thompson Ramo Wooldridge; 1, Resistoflex; 2, Thiokol; 4, Norris-Thermador; 5, Convair; 6, Space Aeronautics Magazine; 8, IBM Federal Systems Div.; 9, GE Missile and Space Vehicles Div.; 11, GE Rocket Engine Section; 12, Parker Seal; 13, Weston Hydraulics; 14, McCormick Selph; 15, Accessory Products Co.; 16, Aeronutronic Systems, Space Technology Div.; 17, IT&T; 18, Aerojet; 101, Pratt & Whitney Aircraft Div. of United Aircraft; 103, Atlantic Research; 104, Douglas Aircraft; 106, Experiment Inc.; 109, Holex Inc.; 110, Lockheed Missile Systems Div.; and 111, Walter Kidde.

Also, 112, Deutsch Fastener; 113, Consolidated Electrodynamics; 115, Wyman-Gordon; 117, Sundstrand Turbo Div.; 118, Wyle Mfg. Corp.; 119, Garrett Corp., Air Research Mfg. Div.; 120, Rocketdyne; 121, The Martin Co.; 122, Cooper Development Corp.; 123, Chance

ARS Semi-Annual Meeting Technical Sessions

	Monday, May 9	Tuesday, May 10	Wednesday, May 11	Thursday, May 12
9:00 a.m.	Human Factors	Magnetohydrodynamics	Guidance and Navigation	Nuclear Propulsion
	Hypersonics	Instrumentation for Combustion Stability Research	Power Systems	
	Lunar Exploration	Hypersonics	Space Observation Systems	Astrodynamics
	Missile & Space Vehicles	New Uses for Liquid Rocket Engines	Underwater Propulsion	
2:30 p.m.	Ion and Plasma Propulsion		Space Law & Sociology	
	Hypersonics	Electrostatic Propulsion	Space Observation Systems	Astrodynamics
	Propellants and Combustion	Support Equipment for Mobile and Hard Launchers (Panel-Secret)	Power Systems	Education
	Human Factors	Solid Rockets Marketing Symposium	Nuclear-Propulsion Instrumentation and Controls	
8:00 p.m.	Latest Events in Spaceflight	Capabilities of Liquid and Solid Rocket Propellant Engines (Panel) (Secret)	(BANQUET)	

Advanced hot gas systems delivered by AiResearch

FOR OUTER SPACE, ATMOSPHERIC AND UNDERWATER STEERING

AiResearch is now in production on two greatly simplified hot gas steering control systems: a reaction control system for outer space flight stabilization and a hot gas actuator control system for terrestrial steering (in the atmosphere and under water).

Both systems eliminate any need for pumps, heat exchangers, accumulators and other apparatus required in earlier control systems. And both systems utilize hot gas, operating off either the main engine or a separate fuel source.

The gas in the outer space reaction control system is fed into a set of nozzles which imparts spin to the missile to stabilize its flight through space.

In the terrestrial hot gas actuator control system the gas is fed into an on-off controlled linear actuator which moves the fins controlling the missile's attitude in the atmosphere or under water. This system also utilizes a concept developed from the AiResearch hydraulic "printed circuit." This approach eliminates complicated plumbing, thereby decreasing the weight and increasing the reliability of the system.

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Also, 205, Beckman and Whitley Missile Products Div.; 206, Lycoming Div. of Avco Corp.; 208, Avco Research and Advanced Development Div. of Avco Corp.; 209, Johns-Manville; 210, Bendix; 213, Bell Aircraft; 214, John Wiley & Sons; 215, Autonetics Div. of North American Aviation; 216, Missile Div. of North American Aviation (Orientations Dept.); 217, Linde Co. Div. of Union Carbide; 218, Consolidated Systems Corp.; 219, GE Flight Propulsion Laboratory Dept.; 220, Hamilton Standard-Div. of United Aircraft; 221, Adel Precision Products; 222, H. I. Thompson Fiber Glass Co.; 223, Westinghouse; 226, Haveg Industries; and 228, Librascope.

18 Sessions Set for National Telemetering Conference May 23–25

Hugh Pruss of Telemetering Corp. of America, chairman of the 1960 National Telemetering Conference, to be held May 23–25 at the Miramar Hotel, Santa Monica, Calif., recently announced the program for the meeting.

A total of 71 papers have been accepted for presentation at the meeting by Program Chairman Roy Colander, and will be presented in panel form in 16 separate sessions, with three sessions running concurrently. In addition, two workshop sessions are scheduled for the meeting, co-sponsored by ISA, the 1960 host, ARS, ASME, and IAS. Theme of this year's meeting is "Telemetry—Tool for Industry and Defense."

The session schedule is as follows:

May 23, A.M.: Industrial data transmission systems; biomedical measurements; space-data acquisition systems. P.M.: General rf components and techniques; missile and aircraft telemetry workshop—"R&D Needed in the '60's"; data processing and presentation—I.

May 24, A.M.: PCM progress; transducers; ground stations—new components and techniques. P.M.: Industrial supervisory control; missile and aircraft flight-data systems; telemetry techniques—I.

May 25, A.M.: Data processing and presentation—II; missile and aircraft environment measurement; general transistorization progress. P.M.: Industrial Telemetry Workshop—"What We Really Need Is . . . "; telemetry techniques—II; reliability in telemetry.

Another feature of the meeting will be displays featuring the latest in telemetry equipment and techniques by leading manufacturers in the field. These will be shown in two large halls adjacent to the rooms in which the technical sessions will be held. Another highlight of the meeting will be the annual banquet and the presentation of the 1960 Telemetry Award.

American Rocket Society

500 Fifth Avenue, New York 36, N. Y.

Founded 1930

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St. Louis Section Presenting UCLA Space Technology Course

The ARS St. Louis Section, in cooperation with McDonnell Aircraft Corp., is presenting for members and other interested persons the outstanding series of filmed lectures on space technology prepared and distributed by the Univ. of California.

ARS-IRE Technical Conference Set in Cincinnati April 12–13

A large turnout of leading scientists and engineers, who will discuss research problems related to outer space, is anticipated at the annual Spring Technical Conference and Exhibition, April 12–13, at the Hotel Alms in Cincinnati, Ohio. The Conference on "Data Processing and Its Application to Outer Space Research," is co-sponsored by regional chapters of ARS and IRE.

C. S. Draper, director of MIT's Instrumentation Lab and chairman of the U.S. Inventors' Council, will preside over a panel on "Inertial Guidance for Missile and Space Vehicle Applications"; T. H. Bonn, senior staff scientist, Sperry Rand Corp., "Electronic Data Processing Comes of Age (Systems)"; and Joseph Kaplan, chairman of the U.S. National Committee of the 1957–58 IGY, "Objectives and Accomplishments of the International Geophysical Year."

Registration will take place on Tuesday, April 12, from 8:30 a.m. to 5:00 p.m. The more than 35 industrial exhibits will be open to the public.

SECTION NEWS

Arrowhead: In January, the Section heard a very interesting talk by

One of a series

Payoff in portable photons

Samarium-145, Samarium-153, Gadolinium-153.
Scientists at the General Motors Research Laboratories began three years ago to measure and re-evaluate the nuclear characteristics of these rare earth isotopes – their half-lives, photon emissions, thermal neutron cross sections.

Conclusion: the radioisotopes had attractive possibilities in industrial and medical radiography, emitting almost pure gamma rays or X-rays (photons) in the low energy range of 30 to 100 kev.

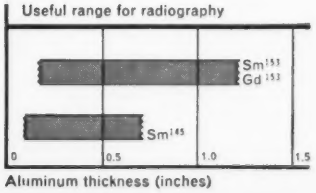
The transition from research to hardware came through two key developments. First, cermet pellets were fabricated using only a few milligrams of the rare earth oxides. Then the irradiated pellets were packaged in special bullet-size holders.

The resulting small, sealed radiographic sources are now being field and laboratory tested. Two excellent applications: "inside-out" checks of hollow shapes inaccessible to X-ray tubes, and radiography of thin steel sections and low density materials such as aluminum or human bone. For example, a recent medical milestone was a chest radiograph of a living person made with a Sm^{153} source. The portable exposure unit to shield the source weighed only 18 pounds.

This isotope radiography program is but one example of the work underway in GM Research's modern isotope laboratory – work that means, through science, "more and better things for more people."

General Motors Research Laboratories

Warren, Michigan



Sm^{153} exposure unit.

On the calendar

1960

April 3–8	EJA Sixth Nuclear Congress, with ISA cooperating, New York, N.Y.
April 4–5	Solar Energy Symposium, Univ. of Florida, Gainesville, Fla.
April 4–8	AGARD Symposium on High Mach Number Airbreathing Engines, Milan, Italy.
April 6–8	**ARS Structural Design of Space Vehicles Conference, Santa Barbara Biltmore, Santa Barbara, Calif.**
April 6–8	National Meeting of the Institute of Environmental Sciences, Biltmore Hotel, Los Angeles.
April 11–13	AIEE Special Conference on Electrical Engineering in Space Technology, Baker Hotel, Dallas, Tex.
April 11–14	ASM Weather Radar Conference, San Francisco.
April 21–22	AIME Southwest Metals and Minerals Conference on Metals and Minerals for the Space Age, Ambassador Hotel, Los Angeles.
April 21–22	Annual Heat Transfer Conference, Oklahoma State Univ., Stillwater, Okla.
April 25–26	The Combustion Institute Western States Section Spring Meeting, Palo Alto, Calif., sponsored by Lockheed Aircraft Corp.
April 25–29	41st Annual Convention of American Welding Society, Los Angeles.
April 25–29	AGARD Boundary Layer Research Symposium, London.
April 27–28	American Society for Metals Tri-Chapter Meeting on Materials—Key to Spaceflight, Sheraton Gibson Hotel, Cincinnati, Ohio.
April 27–30	American Meteorological Socety General Meeting with AGU, Washington, D.C.
April 28–29	WADD Symposium on Closed-Circuit Respiratory Systems, Wright-Patterson AFB, Dayton, Ohio.
May 2–5	ISA Sixth National Flight-Test Symposium, San Diego, Calif.
May 3–5	IRE-AIEE Western Joint Computer Conference, San Francisco.
May 9–11	ISA Third National Power Instrumentation Symposium, San Francisco State College, Calif.
May 9–12	**ARS Semi-Annual Meeting and Astronautical Exposition, Ambassador Hotel, Los Angeles.**
May 9–12	ISA Instrument-Automation Conference and Exhibit, Civic Auditorium, San Francisco.
May 11	Symposium on "Medicine in The Space Age," Statler-Hilton Hotel, New York, N.Y., sponsored by Medical Society of State of New York.
May 23–25	**ISA, ARS, IAS, AIEE National Telemetering Conference, Miramar Hotel, Santa Monica, Calif.**
May 24–28	Japanese Rocket Society 2nd International Symposium on Rocketry and Astronautics, University Club, Tokyo.
May 26–27	"Psychophysiological Aspects of Space Flight" Symposium, by invitation, School of Aviation Medicine Aerospace Medical Center, San Antonio, Tex.
June 1–3	6th Annual Radar Symposium, Univ. of Michigan Willow Run Laboratories, Ann Arbor, Mich.
June 15–17	1960 Heat Transfer and Fluid Mechanics Institute, Stanford Univ., Stanford, Calif.
June 20–23	AGARD Avionics Panel on Radio Wave Absorption, Athens, Greece.
June 25–July 5	AACC, ISA, ASME, IRE, AICHE 1st International Congress for Automatic Control, Moscow.
July 10–22	Underwater Missile Engineering Seminar, Pennsylvania State Univ., University Park, Pa.
July 18–19	**ARS Propellants, Combustion, and Liquid Rockets Conference, Ohio State Univ., Columbus.**
July 21–27	3rd International Conference on Medical Electronics, sponsored by Institution of Electrical Engineers and International Federation for Medical Electronics, Olympia, London.
Aug. 15–20	**11th International Astronautical Congress, Stockholm, Sweden.**
Aug. 15–26	Summer Institute on Nondestructive Testing, Sacramento State College, San Francisco.
Aug. 23–25	1960 Cryogenic Engineering Conference, Univ. of Colorado, Boulder, Colo.
Aug. 29–Sept. 2	The Combustion Institute 8th International Symposium on Combustion, CalTech, Pasadena, Calif.
Aug. 31–Sept. 7	10th International Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.
Sept. 26–30	3rd ISA Instrument-Automation Conference and Exhibit, N.Y. Coliseum, N.Y.C.
Sept. 27–30	**ARS Power Systems Conference, Miramar Hotel, Santa Monica, Calif.**
Oct. 10–12	**ARS Human Factors and Bioastronautics Conference, Biltmore Hotel, Dayton, Ohio.**
Oct. 20–21	Hypervelocity Projection Techniques Conference, Univ. of Denver, Colorado.
Dec. 5–8	**ARS Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C.**

guest **Knox Millsaps,** chief scientist of the Air Force Missile Development Center (Holloman), on "Mechanical Testing on High Velocity Tracks." Dr. Millsaps presented in his inimitable manner the background of the design and construction of the 35,000-ft track at Holloman, the type and purpose of the testing that is done, and instrumentation problems associated with high-velocity, short-duration runs. At the conclusion of his talk, he showed a movie of some testing that has been done and of facilities and instrumentation associated with the sled track.

The Arrowhead Section was honored at this meeting by the attendance of **Roy Marquardt,** president of Marquardt Corp.

—William H. Grip

Cleveland-Akron: The February meeting featured USAF **Capt. R. C. Fruge Jr.,** who discussed "Aerial Recovery of Parachute-Borne Payloads by Fixed- or Rotary-Wing Aircraft." His excellent talk was complemented by a brief movie and slides.

The February meeting was held jointly with the local IAS Section. Such intersociety meetings have become annual events for this Section and, we believe, represent a high level of professional fellowship between the societies.

—Richard G. Gido

Columbus: The January meeting of the Section was held at Battelle Memorial Institute with 27 members and guests attending. The speakers for the evening were **Loren E. Bollinger,** assistant supervisor of the Ohio State Univ. Rocket Laboratory, and **Michael C. Fong,** research associate at the Laboratory, who discussed "Formation of Detonation Waves in Combustible Gaseous Mixtures." After outlining the physical properties of deflagration and detonation waves, they described and illustrated with slides the experimental apparatus, instrumentation, and techniques used at the OSU Rocket Lab to investigate the formation of detonation waves; the results of measurements of detonation induction distances and velocities for several commonly used rocket fuels; and current work on the development of a correlation function for predicting induction distance.

The February meeting was a field trip to Perkins Observatory, operated by Ohio State and Ohio Wesleyan universities. Speaker and host for the evening was **Arne E. Slettebak,** observatory director, who discussed "Astronomical Observations from Above the Earth's Atmosphere." He outlined current plans for studies of heavenly bodies and of various por-

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Design a miniaturized camera system for taking "snapshots" from a satellite. Drastically reduce bandwidth to conserve power, yet maintain high resolution picture quality. The entire unit must operate unattended in a space environment.

Astro-Electronic Products Division took these demands in stride and developed several electronic camera systems scheduled for use in space science experiments. One of them is pictured above.

A special, ruggedized ½-inch Vidicon gives this compact camera a TV resolution capability of 500 lines. Because still pictures are to be transmitted, video bandwidth is cut to 62.5 kc by using a very slow (2 sec.) scanning rate. A specially designed, ruggedized shutter, designed for minimum of 100,000 operations, immobilizes the image and eliminates smear. The camera, less lens, is only 5 inches in length and weighs approximately 2 lbs. The transistorized camera electronics, including the power converter, is housed in a container measuring 6 x 6¼ x 3 inches.

Such a camera can be used to look at the earth's cloud cover from space, map the moon, study the solar system, or monitor the space vehicle itself. 1-inch Vidicon versions of these cameras are capable of 800 to 1,000 lines resolution. This is typical of the way AEP approaches problems, going beyond the bare requirements to develop space systems which can adapt to meet the needs of tomorrow.

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1960 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
April 6–8	Structural Design of Space Vehicles	Santa Barbara, Calif.	Past
May 9–12	ARS Semi-Annual Meeting and Astronautical Exposition	Los Angeles, Calif.	Past
May 23–25	National Telemetering Conference	Santa Monica, Calif.	Past
July 18–19	Propellants, Combustion, and Liquid Rockets Conference	Ohio State Univ.	April 15
Aug. 15–20	11th International Astronautical Congress	Stockholm, Sweden	Past
Sept. 27–30	Power Systems Conference	Santa Monica, Calif.	June 24
Oct 10–12	Human Factors and Bioastronautics	Dayton, Ohio	July 1
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Aug. 25

Send all abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

tions of the electromagnetic spectrum with a space observatory, and discussed problems of alignment and environmental control for a telescope located in space. Dr. Slettebak stated that a 300-lb satellite will be required to conduct solar studies from space. The presentation concluded with a slide of the newest Russian photograph of the hidden side of the moon.

After the meeting, the 56 members and guests, including several family groups, toured the observatory. Alignment of the 69-in. reflector, fifth largest in the U.S., was demonstrated. Fortunately, the sky was unusually clear, and each person in the group was able to observe a double star and the moon. This very enjoyable evening was concluded with refreshments.

—Tobenette Holtz

Dayton: The January dinner meeting, held at the Officers Mess at Wright-Patterson AFB, was attended by a standing-room crowd of over 250 members and guests who gathered to hear **Scott Crossfield,** chief test pilot for North American Aviation, discuss his participation in the X-15 project.

After his talk, Crossfield was asked if he would like to be the pilot if the X-15 were orbited. He replied simply, "Of course." Asked about his reactions in some 29 min of X-15 flight at speeds up to 1400 mph and altitudes to 65,000 ft, he replied: "If you have emotions, you don't belong in the aircraft. There is too much to do."

Needed to orbit the X-15 now would be a first-stage booster like the 1.5-million-lb-thrust Saturn engine. According to Crossfield, both the X-15 vehicle and the MC-2 full-pressure suit in which he flies would be adequate for orbital flight. The length of time a man could stay in orbit would depend on the oxygen and food which he could pack into the cockpit, he said.

—Donald E. Bolton

Florida: The Section's slate of officers for 1960 is as follows: Lt. Col. P. B. Peabody, president; R. V. Godfrey, vice-president; Edward J. Kizak, secretary; and Hubert C. Normile, treasurer.

Holloman: The Section held its February dinner meeting at the Officers Club at Holloman AFB. A large crowd, including many wives of members, attended to hear the featured speaker, **Brig. Gen. Don D. Flickinger,** discuss the "Current Status of Biomedical Space Investigations." General Flickinger is special assistant to the commander of ARDC for bioastronautics.

General Flickinger's talk centered around Project Mercury, part of the national program for placing man in space. He listed the milestones expected in the program as essentially the following: Short-range flights (to be provided by the X-15 program); orbital flights (the simplest vehicle); orbital flights (the advanced concept—several men for several days); permanently manned orbiting

Cal Poly Chapter Receives Charter

Officers of the ARS student chapter at California State Polytechnic College, San Luis Obispo, Calif., dine with ARS President Howard Seifert and their faculty adviser before charter-presentation meeting. From left, Dalton Sherwood, program chairman; Phillip A Bohm, president; Dr. Seifert; Daniel W. Hancock, secretary; Ray Mercado, treasurer; Ken Pauley, vice-president; and Clifford Price (with mustachio), faculty adviser.

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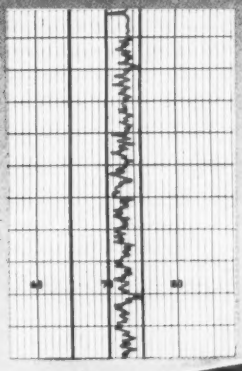

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space laboratory; manned flight to the vicinity of the moon; and manned landing on the moon and return.

The critical biomedical factors seen by him are: Reliability of life-supporting systems; man's reaction to the weightless state; the ways and means to accurately measure and monitor physiological functions; and bioradiation effects.

Slides and motion pictures shown by Gen. Flickinger on the work throughout the United States, and particularly at Cape Canaveral, gave very graphic evidence of the program in progress.

A very unusual demonstration of the cost of the rocket or space program was given by a chart showing the relative cost for shipping charges. The cost is $5 to move 1 ton 1000 miles by ocean surface vessel; $45 to move 1 ton 1000 miles by railroad train; $420 to move 1 ton 1000 miles by aircraft; and *$1 million per pound for a 300-mile orbit of a space vehicle.*

Gen. Flickinger concluded his discussion with the statement that the space program is the greatest challenge this country has ever faced. "There is more involved than just competition with the Russians and the ability to get there first. The real issue is whether or not a free society can maintain scientific and technological superiority over a controlled society."

—**Harry H. Clayton**

Indiana: Over 100 persons attended each of three closely spaced meetings of the section, now under the leadership of President Donald L. Crabtree, research assistant at the Purdue Univ. Jet Propulsion Center.

Rodney D. Stewart of Thiokol, past-president of the Alabama Section, spoke to the section on January 21. His topic was "The Birth of the Large Solid Rocket," and his talk centered on some of the advantages and disadvantages of solid rocket systems, and particularly problems involved with the scaling up of a solid rocket from a smaller prototype.

The first of two February meetings featured **H. B. Ellis,** head of engineering research for Aerojet. His talk concerned liquid rocket combustion studies which had been carried out by Aerojet, and primarily those employing wedge motors. Slow-motion films of these motors illustrated some of the problems encountered in this area, including combustion instability and incomplete combustion.

Leslie J. Sullivan of Martin-Denver, spoke to the Section a week later about the Titan ICBM program. Discussed were the program management, the integrated missile facility at Denver, and the test program. The presentation also included a new motion picture on the Titan.

—**George R. Schneiter**

Maryland: In spite of the threat of ice on the streets and highways, there was a good turnout in January to hear **George E. Barlow** of the Australian Joint Services Staff in Washington describe the Woomera Missile Range. In 1947, by agreement between the United Kingdom and Australian governments, an area of the Central Australia desert was set aside for testing of rocket weapons. The Australian organization which controls this project is known as the Australian Weapons Research Establishment. Today the range extends a distance of 1250 miles from the launching area at Woomera, South Australia, to the northwest Australian coast. The Establishment's research laboratories at Salisbury, near Adelaide, employ 350 graduate engineers and scientists in the management of tests and in research and development on instrumentation, test facilities, and data acquisition and processing. Australian developments in the testing field have included the Jindivik target drone, special cameras and lenses, and automatic processing systems for telemetry and Doppler radio data.

—**Harold J. Hasenfus**

New England Section Panel Discussion

This panel, discussing the question: "Is the Public Getting the Full Story on Our Space Program?" brought out a large audience for the February meeting of the New England Section. Left to right, Robert C. Cowen, *Christian Science Monitor;* Walter T. Bonney, NASA; Irwin Hersey, ARS staff; Arthur Kantrowitz, Avco; Norman Baker, *Space Business Daily;* Wilson B. Key, Boston Univ.; and Ian Menzies, *Boston Globe.*

New England: More than 100 members of the Section and guests turned out for a panel discussion by representatives of the press, government, industry, and education on the question "Is the Public Getting the Full Story on Our Space Program?" held at the MIT Faculty Club on the evening of February 24.

Arthur Kantrowitz, director of the Avco-Everett Research Laboratory, moderated the discussion. Panelists were **Norman Baker,** publisher and editor, *Space Business Daily;* **Walter T. Bonney,** NASA director of public information; **Robert C. Cowen,** natural science editor, *Christian Science Monitor;* **Irwin Hersey,** ARS director of publications; **Wilson B. Key,** Journalism Dept., Boston Univ.; and **Ian Menzies,** science editor, *Boston Globe.*

In the course of the discussion, the panel turned its attention to such questions as whether the press gets the full story from industry and the government; whether the press is in a position to get this story; whether the public cares or not; and what can be done to improve communications in this vital area.

The consensus of opinion was that the press is in a position to get the story, but all too frequently does not because of incompetence on the part of reporters assigned to the space beat, failure to realize the full significance of important developments, and overdependence on press handouts. Meanwhile, the public does not get the full story for all of the above reasons, as well as editorial indifference to the subject. The question was also raised as to whether the public really does care to learn about the subject, and some panel members felt that this was not necessarily true.

In the course of the discussion, the conversation veered away from the press and the public to a consideration of the national space program in general and what can be done to speed up the program and insure against remaining behind Russia in the space race. The discussion produced a number of searching questions from the floor, and informal talks went on long after the meeting was officially adjourned shortly after 10 o'clock.

—**I.H.**

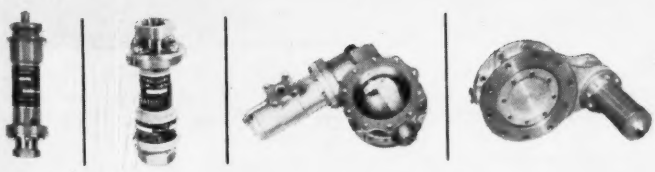
New York: Some 350 members and guests braved one of the worst nights

Cryogenics

FOR THE FRINGES OF SPACE

When North American's X-15 carries man into the fringes of space, fourteen Stratos valves serving vital functions will be working away in its interior. These light, high-performance valves, typical of Stratos' broad cryogenics capabilities—both system and component—were designed and produced at its Western Branch.

Valves supplied for the X-15 include: butterfly valves for LOX and ammonia system; and 700 and 3900 psi relief valves.



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New York Section Forum Draws Large Attendance

of the winter to turn out for the New York Section's Forum on "The Sixties: Showdown Period for U.S. Space Technology," held at beautiful Caspary Hall, part of The Rockefeller Institute, on the evening of February 25.

T. F. Walkowicz, associate of Laurance S. Rockefeller, was moderator, while the keynote address was delivered by **Simon Ramo,** executive vice-president, Thompson Ramo Wooldridge. Panelists included **Todd G. Alexander** of Auchincloss, Parker and Redpath and **Armand G. Erpf** of Carl M. Loeb, Rhoades and Co., representing the financial community; **Joseph G. Gavin Jr.,** chief missile engineer, Grumman, representing industry; **George Gerard,** associate director of research, NYU College of Engineering, representing the educational community; and **Richard Witkin,** aviation editor of *The New York Times,* representing the press.

In keynoting the discussion, Dr. Ramo noted that no nation, however powerful, will be able to monopolize every important field of science. In astronautics, for example, neither the U.S. nor the U.S.S.R. will be able to control all of space and deny entry to it to its rival. "Compared with the Russians in their future progress in space," he noted, "we will do better than they if we, rather than they, make the wisest choices as to how best to use what for each of us are limited resources."

Stressing the need for a vast increase in basic research, and not space research alone, Dr. Ramo pointed out that we are now actually engaged in a "Science Olympics," in which the recognized leader will win on total points in an over-all contest covering many events, even though he may lose some important individual events.

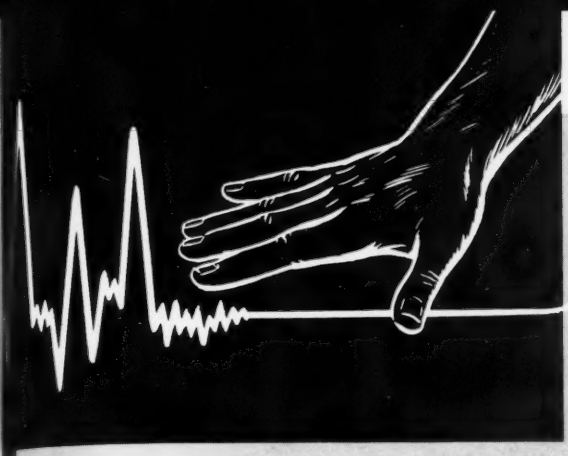
Our No. 1 problem for the Sixties, he added, has to do with something much broader than space. "It is the problem of making the transition smoothly from our present society to the much more highly technological one toward which we are headed. The many needs to effect this . . . include doing more basic research, but they also include revising our pattern of national operations—effecting government reorganization . . . and understanding the proper relationship between national policy and scientific potential."

Dr. Ramo's remarks were followed by a lively discussion in the course of which every member of the panel contributed some acute comments. The panel agreed that the electronics industry would have the greatest growth in the next decade because of space technology and Dr. Ramo commented that, within this field, what he called "intellectronics"—everything in electronics which pertains to the handling of information—would see the greatest advances. The panel also agreed that defining our national goals and policy was of paramount importance; that educating the public for the new scientific society was a major problem; and that leadership from the top was vital

General view of the large audience which attended the New York Section Forum on "The Sixties: Showdown Period for U.S. Space Technology."

Left, keynoter Simon Ramo, executive vice-president, Thompson Ramo Wooldridge, and moderator T. F. Walkowicz, associate of Laurance S. Rockefeller.

On the rostrum, left to right: Todd G. Alexander, of Auchincloss, Parker & Redpath; Armand G. Erpf, of Carl M. Loeb, Rhoades & Co.; Joseph G. Gavin Jr., Grumman Aircraft; Dr. Ramo; George Gerard, associate director of research, NYU College of Engineering; Richard Witkin, Aviation, Editor, *The New York Times;* and, standing, Dr. Walkowicz.



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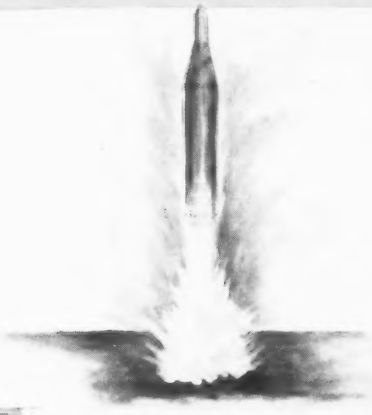
Robinson all-metal MET-L-FLEX® mounting systems are ***now*** protecting certain components and items of sensitive equipment installed in the Atlas, Titan, Polaris, Bomarc, Lacrosse and other important missiles. Advanced space projects will depend heavily upon the specialized engineering resources that are available at Robinson to achieve reliability through environmental control.



aircraft

Today every major commercial and military aircraft including intercontinental and medium range jet bombers, supersonic fighter-bombers and interceptors, trainers, tankers, cargo and reconnaissance planes, are equipped with all-metal mounting systems designed by Robinson to protect many vital components.

surface ships and submarines

Robinson pioneered in the development and production of new ***low frequency*** shipboard mounting systems for the Navy's new single sideband communications equipment. These all-metal mountings have been specified by the Navy for installation in nuclear submarines and surface craft.

vehicles

Rugged, all-metal mounts have been designed, tested, and accepted to protect the latest communications and electronic equipment installed in tanks, trucks, jeeps, command cars, and other military vehicles. The operational life of the electronic components will be extended and reliability increased.

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to our success as a nation in the next decade.

The panel discussion stimulated a number of questions from the floor which panel members attempted to answer without sidestepping, and the meeting could undoubtedly have continued far beyond the 10 o'clock curfew which had been set for it.

Highlights of the forum were presented on a CBS radio program the week following the meeting.

At the January meeting, the following officers were elected for the calendar year 1960: Richard Frazee (re-elected), president; Joseph G. Gavin Jr., vice-president; John S. Taylor (re-elected), treasurer; and Arthur P. Gertz, secretary.

—I.H.

Northern California: The January meeting of the Section was held at the Carriage House in Millbrae, Calif. Following the social hour and dinner, retiring President Jim Arnold introduced the following new officers: Bernard Ellis, president; Fred Hansen, vice-president; Howard Kindsvater, secretary; and Norman Fishman, treasurer.

Guest speaker for the evening, **Howard S. Seifert,** ARS president, then discussed "Programs of the Early Space Age." Dr. Seifert first reviewed the successes, failures, and objectives of all the known U.S. and Russian space programs, and then gave an evaluation of the various propulsion units for the different vehicles and speculations regarding proposed vehicles in terms of known propulsion-development programs. A lively discussion followed Dr. Seifert's presentation.

—H. M. Kindsvater

Orlando: The January technical meeting was held in conjunction with the Orlando Astronautical Society. **William Lazarus** spoke on space-probe testing at the Eglin Range. He had many interesting and colorful slides of the Eglin facilities and missiles tested there. A discussion of some length followed the lecture.

—William E. Krauss

Philadelphia: Guest speaker at the February dinner meeting of the Section was **Henry W. Phillips,** manager of operations administration for the RCA Major Defense System activity in Moorestown, N.J., who presented an unclassified program on the evolution of U.S. national defense systems since the end of WW II.

He noted that the BMEWS system is proceeding exactly on schedule, and added, "In BMEWS we have a giant defensive radar system which is capable of detecting and tracking oncoming ICBM's minutes after they are launched and accurately predicting an enemy ICBM's probable time and point of impact. BMEWS as a defensive project is a positive mission to meet a positive need." An outstanding collection of color slides enhanced the presentation.

New officers of the Section are: John E. Walton, GE Defense Systems Dept., president; Charles S. Stokes, Temple Univ. Research Institute, vice-president; Bernard Cohen, Foote Mineral Co., secretary; and William F. Ashley, GE Missile and Space Vehicle Dept., treasurer.

St. Louis: **Comdr. Malcolm D. Ross** (USN) was the featured speaker at the February dinner meeting, discussing "High-Altitude Balloon Research." An upper-atmosphere physicist in the Air Branch of ONR, Comdr. Ross administers ONR's Stratolab program of upper-atmosphere research with manned plastic balloons, and last year, accompanied by Charles Moore, rose to 81,000 ft to make observations of Venus unimpeded by the earth's atmosphere and obtain relatively clear spectrographic measurements of the perpetually shrouded planet.

In the course of his talk, Comdr. Ross showed several excellent color slides taken during this flight, as well as other balloon ascents. He reported that data obtained in the course of Stratolab experiments indicate the presence of water vapor in the Venusian atmosphere, and that a full report of Stratolab findings would be formally released in the near future.

—Albert E. Cohen

Speaking of BMEWS . . .

H. W. Phillips (center) of RCA, who spoke on the BMEWS system, chats with Abe Bernstein (left), chairman of the Philadelphia Section's Education Committee, as Section vice-president Charles Stokes listens in at February dinner meeting.

Utah Section Ready For a Big Year

At a well-attended dinner meeting in January, presided over by ARS vice-president Harold W. Ritchey (left), Joseph H. McKenna (center), a senior engineer of Thiokol's Utah Div., was installed as Section president for the new year. Richard E. Horner (right), associate director of NASA, was guest speaker at the ceremonies, which marked the beginning of a big year expected for this relatively new ARS section.

Utah: At a January dinner meeting, held at the Hotel Utah in Salt Lake City, new officers for the coming year were installed, with **Harold W. Ritchey,** ARS vice-president, presiding at the ceremonies. Joseph H. McKenna of Thiokol is the new Section president, and Loren Morey of Hercules Power is vice-president.

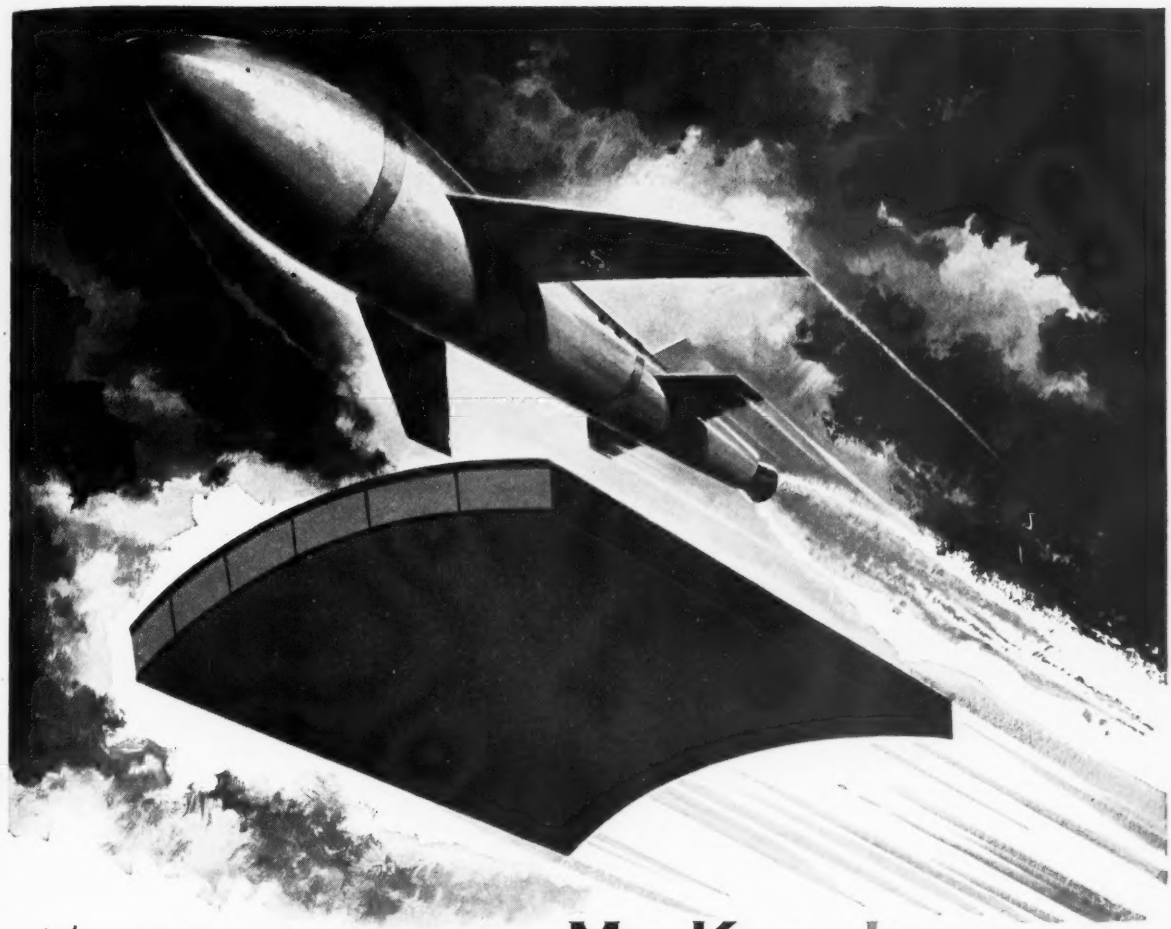
Guest speaker for the evening was **Richard E. Horner,** associate administrator of NASA, who discussed the progress and expectations of NASA programs.

—John McGovern

STUDENT CHAPTERS

St. Louis Univ.: At the February

(CONTINUED ON PAGE 103)



Johns-Manville Announces... MIN-KLAD INTERLOK

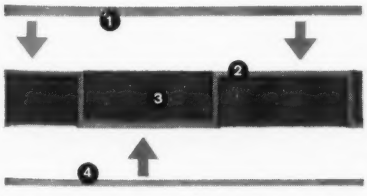
. . . a new structural system interlocking Min-K insulation and high-temperature reinforced plastic

Missile experience shows that in certain heat control situations no one material will perform as well as two (or more)—*an insulation with protective high-temperature facings.*

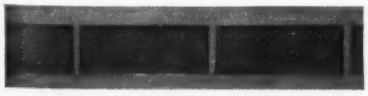
Problem is how to effectively combine these materials into a structurally strong unit? The answer is Min-Klad Interlok—a new structural system that interlocks Min-K insulation and reinforced plastic, metal or other high-temperature facings.

The result: one product that gives the missile designer every advantage of high-temperature plastic or metal foil—strength, toughness, rigidity! Erosion resistance! High heat capacity!

. . . plus the outstanding advantages of Min-K insulation—an insulating core that has the lowest thermal conductivity available for service temperatures up to 2000°F steady-state, and higher for transients. Min-K's thermal conductivity is actually lower than the molecular conductivity of still air.



1) Outer facing, 2) Interlocking web, 3) Core, any one of several Min-K formulations, and 4) Inner facing.



All the above components combine to provide a custom-made structural strong insulating system.

Wide range of facings

For the hot face, the missile designer can specify Min-Klad Interlok in a wide variety of heat-resistant and/or ablating materials—asbestos-phenolic (ARP-40), and similar reinforced plastics, as well as stainless steel and other heat-resistant metal foils and meshes. For some requirements, the cool face can be made of a different material—for example, one that offers characteristics required for bonding or fastening to other surfaces and parts.

Like all J-M Aviation insulations, Min-Klad Interlok is factory-fabricated to your specifications into external skin panels, heat shields, cylindrical liners or component housings of any shape or size. Write today for technical specifications. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

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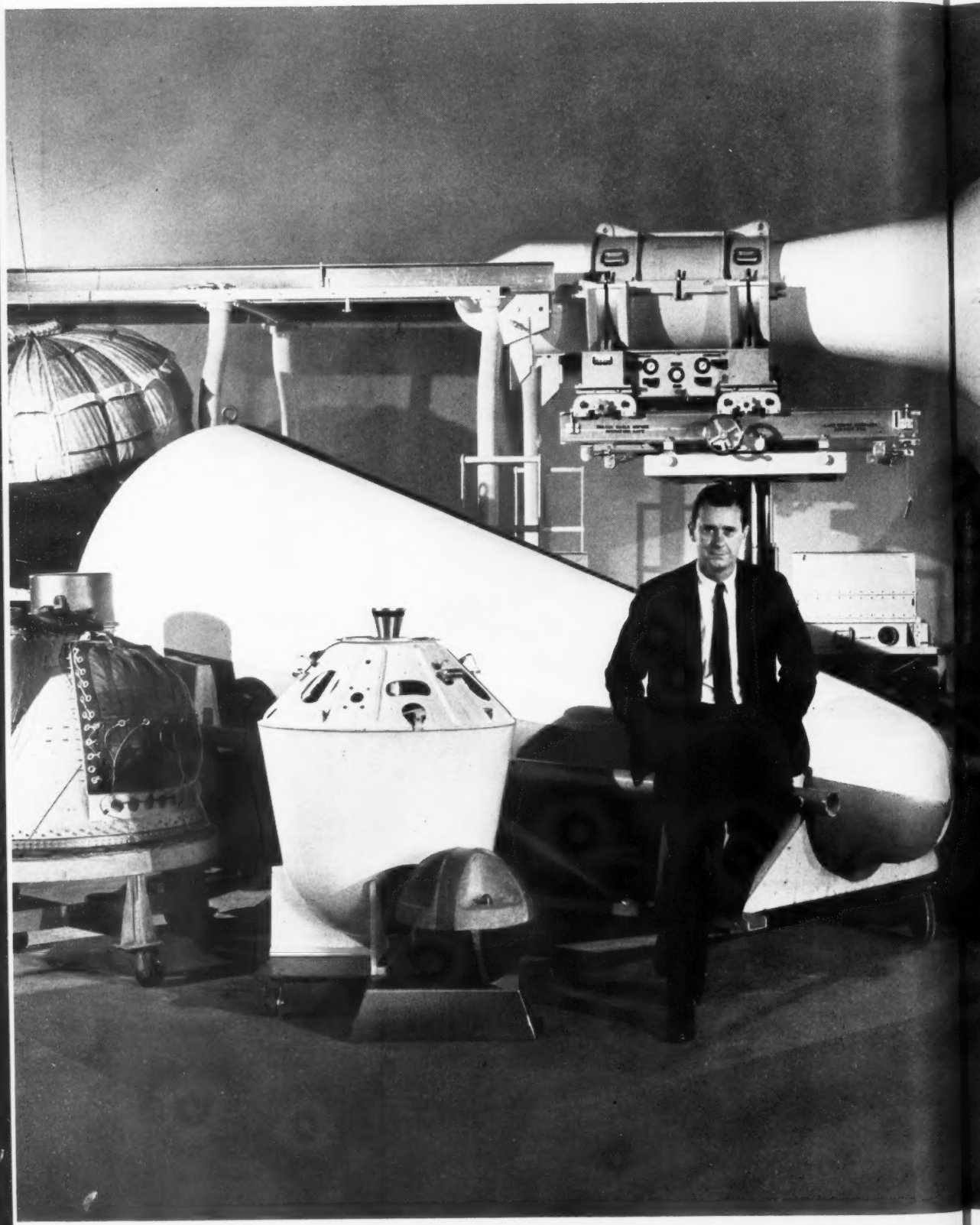
4000 subcontractors are represented
re-entry vehicle "family portrait"



in this unique dramatizing . . .

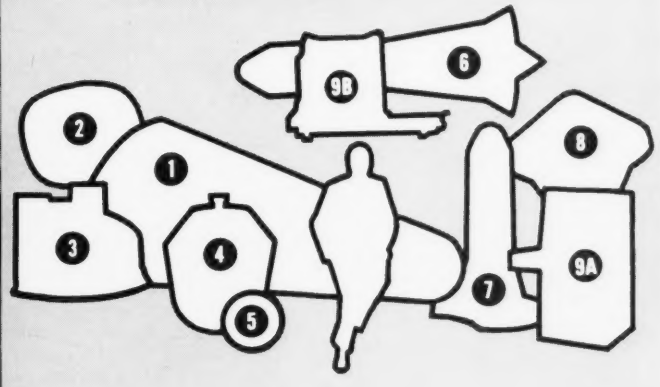
4 years of USAF, G.E., SUBCONTRACTOR re-entry vehicle progress

The key to this progress has been teamwork . . . teamwork between General Electric's Missile and Space Vehicle Department, the Ballistic Missile Division and the Ballistic Missile Center of the United States Air Force and the over 4000 small and large subcontractors alike who have helped MSVD make so many vital contributions to U.S. re-entry vehicle progress.

IN 1959 ALONE, the following figures indicate the emphasis MSVD placed upon this important factor of subcontractor teamwork on Air Force projects.

- Over 35,000 different purchase orders were placed by MSVD on subcontractors in 1959.
- More than 25,000 of these MSVD purchases were made from "small" subcontractor businesses.
- More than $26,000,000 worth of goods and services were purchased by these 35,000 orders. This amount represented a major portion of the contract dollars received by MSVD.
- And more than $13,000,000 of this $26,000,000 went to "small" business firms.

If you'd like more information about G.E.'s Missile and Space Vehicle Department . . . its subcontracting activities, its re-entry vehicle programs or about any of its space technology activities . . . write to Section 160-70, G.E. Missile and Space Vehicle Department, 3198 Chestnut Street, Philadelphia 4, Pa.



Mr. Hilliard W. Paige, General Manager, Missile and Space Vehicle Department with Air Force re-entry vehicles developed by MSVD.

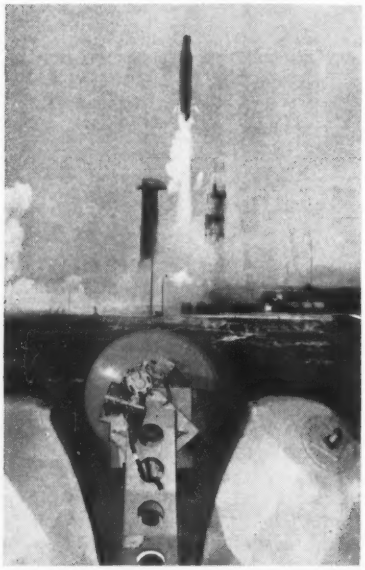
1. RVX-2 Re-entry/Recovery Vehicle, the largest ablation-type re-entry vehicle to travel full ICBM-range and be recovered.
2. Flotation balloon used in recovering USAF-MSVD research re-entry vehicles.
3. Recovery equipment package for RVX-2.
4. Satellite Aeromedical Re-entry/Recovery Vehicle for USAF Discoverer Program.
5. Mark-2 recoverable Data Capsule which flew in Thor re-entry vehicle and returned first films from outer space.
6. Mark-3, an advanced operational-type re-entry vehicle for Atlas.
7. RVX-1, first ablation-type re-entry vehicle to be recovered after full ICBM-range flight.
8. Mark-2, first U.S. operational heat-sink re-entry vehicle now in use on USAF Thor and Atlas missiles.
9. Typical ground support equipment developed by MSVD for USAF use. (A) Mark-2 prelaunch check-out console. (B) Mark-3 missile mating equipment.

MISSILE AND SPACE VEHICLE DEPARTMENT

GENERAL ELECTRIC

A Department of the Defense Electronics Division

Radar Point of View



The picture shows what you would see from inside a radome as a ground antenna of GE's radio-command guidance system for Atlas takes position and velocity measurements on a rising missile. GE Defense Systems Dept. has prime responsibility for Atlas' radio command guidance.

Observation Satellites

(CONTINUED FROM PAGE 29)

It is of interest to consider how much of the earth is seen with varying viewing angles off-vertical from various satellite altitudes.

With reference to the illustration at the top of page 28 and the quantities labeled thereon, it is possible to calculate both slant range, S, and distance along the ground, W, from the subpoint, D. Approximate formulas yield solutions for S and W directly, and have this advantage over the exact formulas.

Exact solution:

$$S = [h + R\,(1 - \cos\theta)]\ \sec\phi$$

$$W = R\theta\ (\theta \text{ in radians})$$

$$\theta = \sin^{-1}\left[\frac{R+h}{R}\ \sin\ \phi\right] - \phi$$

Note: $\theta < 90°$

Approximation:

$$S = \left[h + {}^1/_2\frac{h^2}{R}\ \tan^2\phi\right]\ \sec\phi$$

$$W = [(s\sin\phi)^2 + (s\cos\phi - h)^2]^{1}/_{2}$$

Flat-earth approximation:

$$S = h\ \sec\phi$$

$$W = h\ \tan\phi$$

The table on page 28 gives the values of slant range and ground distance for values of satellite altitudes ranging from 100 to 10,000 miles for three values of ϕ — 30, 45, and 60 deg. This table was computed by each method given above. Inspection of the table will reveal over what regions the two approximations are useful. This depends to a large extent on the purpose of the calculation. The last four altitudes listed in the table are for 1000, 2000, 5000, and 10,000 miles. Note that the maximum value ϕ can take—at tangency with the earth—is only 16.5 deg at the 10,000-mile altitude.

Tools for Observation

Observation can be carried out in many ways using sensors operating in different portions of the electromagnetic spectrum. As tools, we have the unaided human eye; photography, with its ability to record in permanent form large amounts of detailed information; radar observation techniques; and infrared systems. Weather observation, not easily categorized by wavelength, draws on all these sensors, plus others which are peculiarly its own. However, as discussed in a subsequent section, cloud photography may be a major tool of meteorological observation and forecasting systems.

The major reasons for the interest in observation from satellites stem not only from the possibility of taking pictures at altitudes of hundreds of miles, but also from consideration of the large areas which can be covered cyclically. The major reason for close examination of photographic techniques for use in satellites is the high-resolution capability of photography.

The major emphasis in this paper will be on photographic film systems. Television techniques, of course, are entirely applicable to use in observation satellites. TV systems have many potentialities which indicate an enormous role in, and range of applications to, observation systems. This is especially true for long-lasting systems. Advanced television tubes have applications to observation at very low light level. At this time, however, television formats and resolution are much smaller than those achievable with film. A full comparison of television and film systems will not be made here.

The ground resolution of a high-quality photographic system in a satellite may be of the order of, say, 5 to 100 ft, which, from altitudes of 300 miles, corresponds to angular resolutions of from less than 1 sec of arc to perhaps 15 sec. Infrared ground-imaging systems and radar systems are characterized by resolution measured in, say, tenth's of a degree. Eventually, these systems will find applicability in observation satellites, not only because resolution will be vastly improved, but also because these non-visual sensors have unique properties, such as response to thermal gradients and the ability to "see" in the dark (infrared and radar) and through weather which would make photography impossible (radar).

The concepts and formulations which have preceded these remarks, as well as those which follow, apply easily and as well to TV systems, except for the important case of physical recovery of data.

As we have implied, an important parameter in describing the performance of observation systems is *resolution*. It is measurable, it is fundamental, and it is widely discussed; but its use is difficult and often misunderstood, and its limitations are not generally appreciated.

As used originally by astronomers, "resolution" described the ability of a telescope to separate double stars. As it has come to be applied over the years to photographic systems, resolution refers to the ability of a film or a lens, or a combination of both, to render barely distinguishable a standard pattern consisting of black and white lines. When we say the resolution of a system is 10 lines per millimeter, we mean that the pattern whose line-plus-space width is 0.1 mm is barely resolved, that finer patterns are not resolved, and that coarser patterns are more clearly resolved.

There continues to be much justifiable discussion and criticism of the use of this single parameter to specify performance, for it fails to describe the character of the resolution at all points other than the last, or threshold, value. Nevertheless it is a convenient measure, useful in making gross comparisons and evaluations.

It is possible to test film and to obtain resolution values essentially independent of the lens, and lenses may certainly be tested visually without film. In 1941, the author proposed a method of evaluating the combined effects of film and lens. If the resolution of the film is R_F lines per millimeter, and the resolution of the lens R_L lines per millimeter, then the resolution achievable by the combination is given by $1/R_{F+L} = (1/R_F) + (1/R_L)$.

Consideration of this formula and its implications should shed light on fruitless discussions, common among photographers, as to whether the film or the lens is the limiting factor in achieving resolution. In short, un-

Whereabouts Unknown

After its towering "sail" slides beneath the sea, a U. S. Navy Polaris submarine may not surface again for many a month. But "out of sight" will not mean "out of mind"—least of all for any potential aggressor. For who could forget that each nuclear-powered submarine could launch 16 Polaris missiles in as many minutes—or that each Polaris missile could destroy a major strategic target 1200 miles away? Lockheed is prime contractor and missile system manager for the Polaris. Aerojet-General makes the solid-propellant rocket motor, General Electric the guidance system.

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less either the film or the lens resolution is at least, say, three times the other, both film and lens mutually interact to lower the resolution achievable by either alone.

This simple, essentially heuristic reciprocal formula can be generalized by addition of terms chargeable to the printing process, the enlarger lens (if used), the atmosphere, image motions, and the like.

Suppose, for example, that the image is subjected to so much blurring motion that the maximum achievable resolution is only 5 lines per millimeter. Clearly a lens-film combination capable of, say, 100 lines per millimeter is of little avail. We can therefore use $R_B = 5$ in this equation, and it is readily seen that this effect of motion dominates.

Thus, more generally, the resolution of a given system, S, is given by

$$\frac{1}{R_S} = \sum^{n} \frac{1}{R_i}$$

where R_i represents the resolution limits of the n separate components.

When aerial photographers refer to a 40-in. lens, they are thinking of focal length. When astronomers refer to a 40-in. lens, they mean the diameter of the objective lens. The reasons stem from basic interests. Aerial photographers are more interested in scale than resolution. Astronomers work closer to the theoretical diffraction limits of their optics than do aerial photographers, who are usually dealing with much wider viewing angles, substantial motions, and other effects which tend to lower resolution. Astronomers are interested in light-collection efficiency (proportional to area of objective) as well as resolution.

Two essentially equivalent and useful formulas for the maximum theoretical performance achievable by diffraction-limited objectives are given below. The first is Dawes' rule, developed for the case of visual examination of double stars:

$$\text{Resolution (seconds of arc)} = \frac{4.5}{\text{Diameter of objective (in.)}}$$

The next formula specifies, for the wavelength regions commonly used in observation or photographic work, the limiting resolution in the focal plane:

$$\text{Resolution (in lines per millimeter)} = \frac{1500}{f/\text{number}}$$

The "f/number" here is the relative aperture, or the focal length divided by the entrance pupil. Thus, fast lenses, characterized by low f/numbers, can, in principle, yield much sharper photographs than do slow lenses.

Both of these formulas should specify the wavelengths of light used, but this would needlessly complicate them and suggest a precision that is quite unwarranted. Formulas of this type are useful primarily in exploratory or preliminary design, and especially in "back-of-the-envelope" calculations.

Ground resolution is a familiar term in all discussions of observation-satellite performance. It is simply the ground dimension equivalent to one line at the limit of resolution. Thus, if a given system yields R lines per millimeter, and the scale number is S, the ground resolution, in familiar units and rounding off slightly, is given as: Ground Resolution (ft) = $S/300R$. Consider the example used earlier, a 6-in.-focal-length camera held vertically at 150-miles altitude. The scale number is 1,584,000. At 10 lines per millimeter, the ground resolution would be approximately

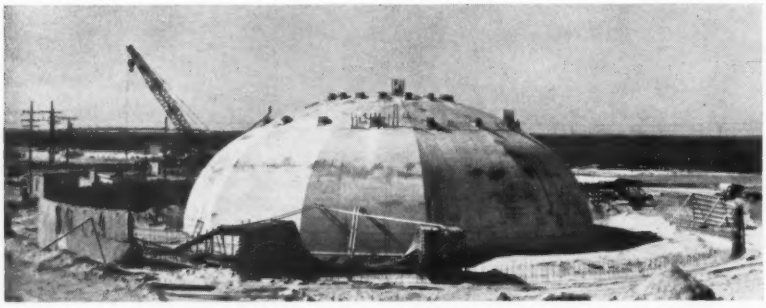
$$G = \frac{1{,}500{,}000}{300 \times 10} = 500 \text{ ft}$$

Many factors enter into assessment of the interpretability of an aerial photograph. Resolution is only one. The particular characteristics of the photographic emulsion used, its graininess, granularity, microcontrast performance curve (or transfer function), the transfer function of the optical imaging system—these are but a few of the factors which predominate. From the formula for ground resolution, one would expect to obtain the same ground resolution by trading resolution and scale number. Thus, one should expect that 10 lines per millimeter at a scale number of 100,000 should yield the same ground resolution as 100 lines per millimeter at a scale number of 1,000,000. However, this type of reciprocity is never the case in either practice or theory.

Several years ago, an instructive series of photographs was prepared by the Boston Univ. Physical Research Laboratory. The number, small size, and detail of these photographs defy any attempt at reproducing them here. Briefly, three excellent aerial photographs of the same scene were secured at scale numbers of 10,000, 20,000, and 40,000. Ground-resolution targets enabled the assessment of the quality level of each of these photographs as being 40 lines per millimeter.

These three photographs were systematically degraded (control being furnished by an auxiliary resolution target mounted adjacent to the negative) from 40 lines per millimeter to 20, 10, 5, 2.5, and 1 line per millimeter. The process may be suspect at the lower numbers, but is undoubtedly correct down to, say, 5 lines per millimeter. Careful and lengthy inspection of these photographs demonstrates the point that 10 lines per millimeter at a scale number of 10,000, which yields the same calculated ground resolution as 40 lines per millimeter at 40,000 scale number, actually yields more information than the latter. Examination of photographs like these furnishes more, but similar, examples, providing a sound basis and insight into the theory and mechanism which explain this phenomenon.

By and large, if one can trade scale for resolution, *one should trade in the direction of lower resolution and*

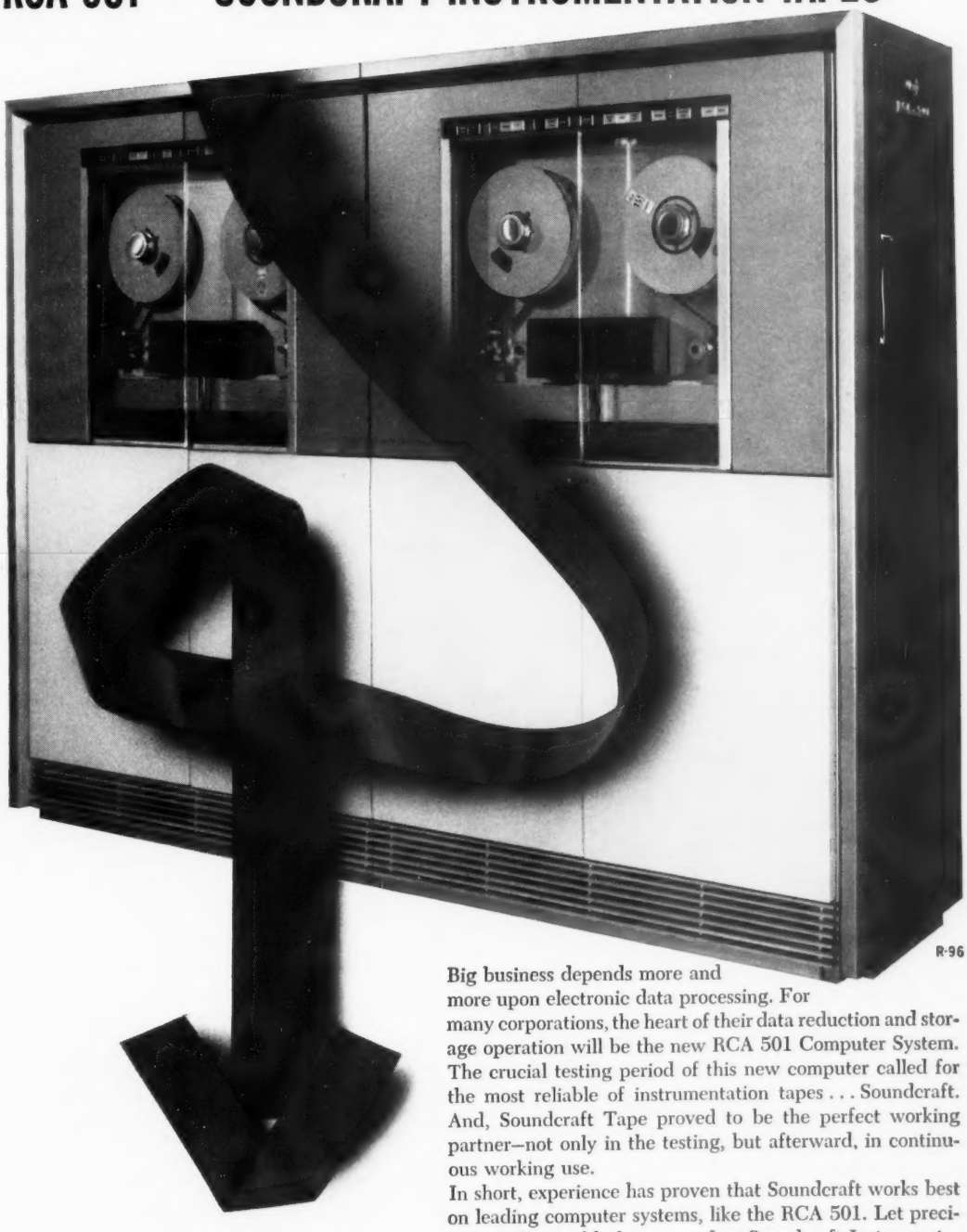


Saturn Blockhouse

The Saturn blockhouse rises on a 65-acre complex for the space vehicle at Cape Canaveral, 1000 ft from the launching pad. About 38 ft high and 156 ft in diam, the blockhouse will have two floors with 10,600 sq ft of working area. Notice the many multichannel cables for controls and communication issuing in the foreground.

WORKING PARTNERS

RCA 501 — SOUNDCRAFT INSTRUMENTATION TAPES



R-96

Big business depends more and more upon electronic data processing. For many corporations, the heart of their data reduction and storage operation will be the new RCA 501 Computer System. The crucial testing period of this new computer called for the most reliable of instrumentation tapes . . . Soundcraft. And, Soundcraft Tape proved to be the perfect working partner—not only in the testing, but afterward, in continuous working use.

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smaller scale number. It follows that the larger the image to be rendered the greater the contrast. This is a characteristic of the transfer function of the film. There are great differences in the graininess characteristics of different aerial photographic emulsions, and these affect interpretability much more than they influence resolution.

Exact Law Holds Dangers

The MacDonald paper from *Photogrammetric Engineering* (see references), which contains an excellent discussion of the problem, also illustrates the difficulty and danger in attempting to formulate an exact law. It states: "It has been found that, for a given photographic emulsion, the level of interpretability of a photograph of resolution R at a scale $1{:}n$ is the same as that of a photograph at resolution $2R$ at a scale of $1{:}\sqrt{2}n$." This is equivalent to the more general formulation that a pair of scale-number and resolution figures (for a given film type), say (S_1, R_1), is equivalent (with respect to interpretability) to a second pair (S_2, R_2) when $S_1 = \sqrt{R_1}/\sqrt{R_2}$. Of course, one could go from any pair (S, R) to any other pair in a series of steps (as in the original formulation), but this procedure, though instructive, is inconvenient. Simple examples will demonstrate the kinds of conclusions which this law produces, and their obviously invalid nature.

Considering a pair of numbers, $S_1 = 3 \times 10^6$, $R_1 = 100$ lines per millimeter, and calculating the value of R_2 when $S_2 = 10^5$ (for equivalence), leads to $R_2 = 1/9$ line per millimeter —truly useless photography! Calculating R_3 for this same series when $S_3 = 10^4$ yields $R_3 = 1/900$ line per millimeter (or, 1 line per 900 millimeters)!

The photographic quality represented by this last calculation is so low that it cannot even be imagined, let alone simulated. Thus this newer formulation leads to conclusions far less acceptable or plausible than does the simple exchange of scale and resolution for equivalent ground resolution.

What are we to make of this? We are left with the important observations—which deserve continued reemphasis—that scale and resolution are not simply tradable (i.e., perfect reciprocity does not exist), and that ground resolution alone, an instructive and useful parameter, must be used with understanding and caution.

Although use of the single parameter of ground resolution requires an accompanying statement of caution and proscription, these conditions are seldom stated explicitly, and many times, even when they are appreciated, they are ignored implicitly.

Nevertheless, for rough planning purposes, it has proven convenient and useful to define and use four broad levels of observational detail, which in terms of ground resolution are:

Level A: 100 K ft (50 to 200 ft); Level B: 20 K ft (10 to 40 ft); Level C: 4 K ft (2 to 8 ft); Level D: K ft (0.5 to 2 ft) $(1/2 \leq K \leq 2)$

The range of a factor of four within each level arises from a practical inability to measure and interpret ground resolution as a fixed number. Causing further difficulty, and of even greater influence on this spread factor, are the variations in conditions and contexts of observation, and variations in the observability of objects within a given object class. Numerous examples could be furnished which would illustrate variations by factors of at least four. Consider, for example, the detectability of, say railroad lines on small-scale photography. All rail lines may not have the same width of cut; some may, from time to time, have ballast which furnishes high contrast with the ground; the extent to which vegetative growth is cleared may vary; etc.

It would be more rigorous and meaningful to define these four levels (A, B, C, D) in terms of a particular combination of scale number, film type, and film-camera resolution (in lines per millimeter), but this gain in rigor makes for inconveniences in discussion. Such a representative series of specifications for the four levels might well be defined in terms of 10-line per millimeter quality on (now obsolete) Aero Super XX film. This quality level and this film were not chosen arbitrarily. Literally millions of aerial photographs taken on this film, and at approximately the 10-line per millimeter level, were examined by photo-interpreters in WW II. With these two qualities fixed, the four levels could be stated in terms of scale (with K ranging from $^1/_2$ to 2, as before) as follows: Level A: 250,000 K; Level B: 50,000 K; Level C: 10,000 K; and Level D: 2000 K.

Minor Discrepancies

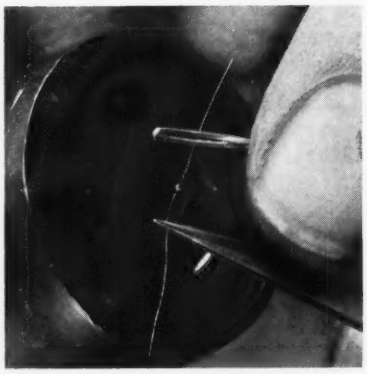
The reader who checks these two (nominally equivalent) formulations for consistency of the ground-resolution equivalents will quickly note a minor and unimportant discrepancy. The advantages of round numbers, coupled with the earlier comments on the imprecise meaning of ground resolution, plus the saving factor of four which causes both ranges to overlap—these permit us to ignore such discrepancies.

An important aspect of the second, more cumbersome formulation of levels in terms of scale, film, and resolution level is that numerous photographs at each of these levels exist and can be studied. Certainly, and obviously, the scale number at Levels B, C, and D are duplicable with ordinary aircraft altitudes and cameras.

For example, the upper limit of Level B is attainable with a vertical 6-in. camera at an altitude of 50,000 ft. Photographs at the smaller scale numbers (which in the language of the aerial photographer are "larger scale") can be secured either at lower altitudes or with longer-focal-length lenses, or by means of a combination of both. For example, a vertically mounted 12-in. camera at 1000 ft yields a scale number of 1000.

There remains the case of Level A. To examine vertical photography at scale numbers of 125,000 to 500,000, one must fly higher than 50,000 ft, as shown in the illustrations on page 27, or use very-short-focal-length lenses (less than 6-in.), or both. On the

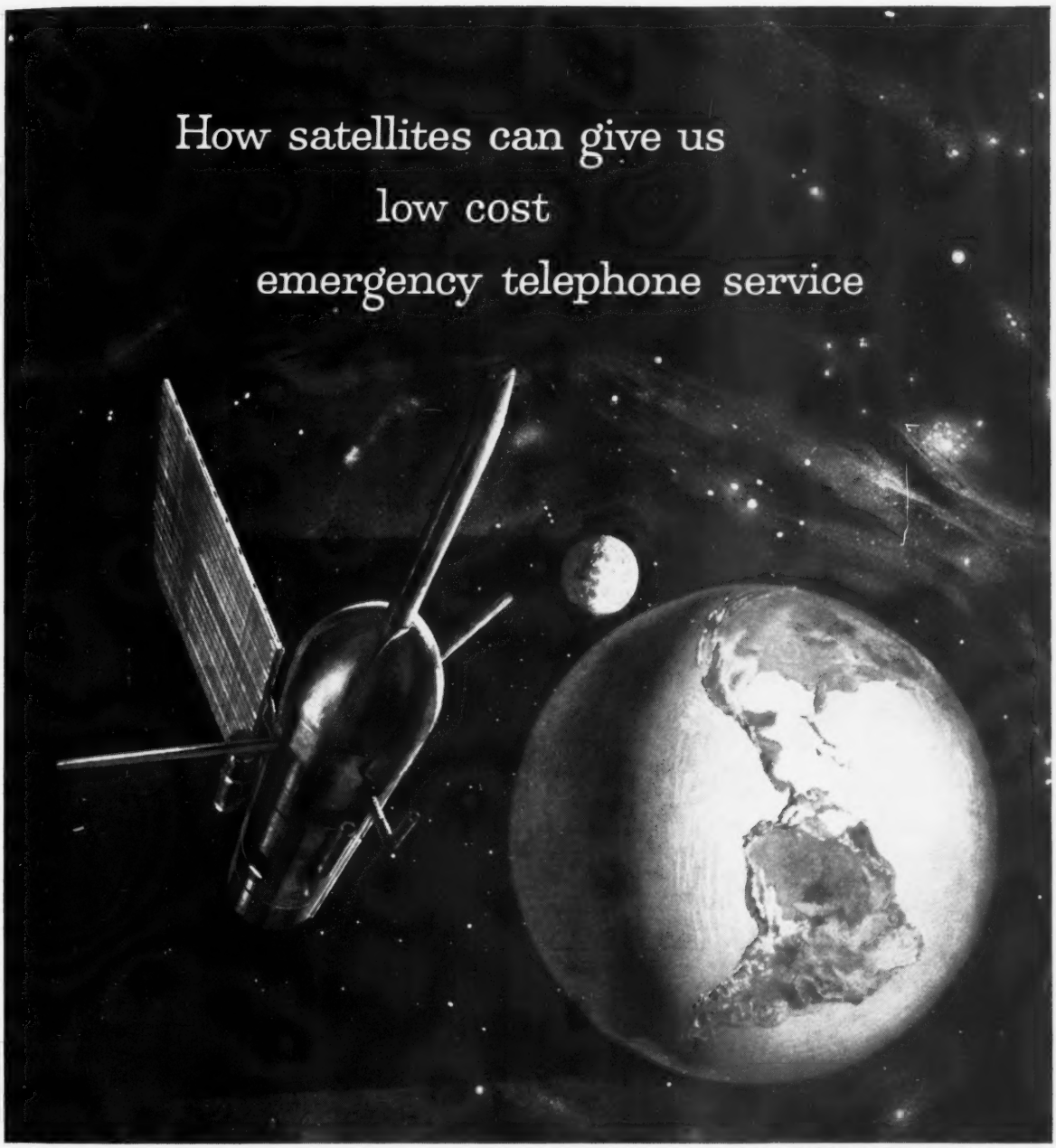
Smaller and Smaller



Bead thermistor for measuring skin temperature on Atlas and Polaris.

The pictured bead thermistor, made by Gulton Industries, is used to take temperature measurements on the inner and outer surfaces of the Polaris and Atlas missiles. Made of manganese-nickel oxide, the thermistor, a 0.010-in.-diam bead mounted on a 0.001-in.-diam wire, can measure temperatures between −76 and 572 F. Such sensors have also been used to measure blood temperature inside a hyperdermic needle, radio-frequency power in the microwave region, and low gas pressures.

How satellites can give us low cost emergency telephone service



Launched by the Douglas-built *Thor* IRBM, satellites like this would relay telephone messages anywhere in the world without costly cables or towers.

Beyond their immediate military necessity, our present rocket and missile programs promise many vital peacetime benefits to us all...

Well past the drawing board stage are plans to use satellites as a low-cost emergency stand-by system to relay telephone calls around the world.

Your call would be beamed to a satellite, then bounced back to a receiving station on Earth. Cost is estimated at a fraction of what must be spent to install and maintain cables or radio relay towers.

While satellite telephone service is still in the future, *Thor*—the rocket that can put it into being—is thoroughly proved. Built by Douglas, maker of the DC-8 jetliners, *Thor* has been successful in more than 90% of its shots. It is key booster in the "Discoverer" firings and launched the first nose cone recovered at ICBM range.

Thor is another product of the imagination and experience gained by Douglas in 20 years of missile development.

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other hand, hundreds of thousands of photographs exist which were captured with tri-metrogon assembly of cameras. The tri-met system consists of three 6-in. mapping cameras, each taking 9 x 9-in. photographs. The center camera is mounted vertically, and the side cameras mounted with their axes depressed 30 deg from the horizontal. Average scale number may be defined as the geometric mean of the two scale numbers in the x and y directions at a point. It is readily calculable that at the center (or principal point) of oblique tri-met photographs taken from 45,000-ft altitude, the average scale number is very close to 250,000. Because scale numbers increase very rapidly in such oblique photographs, the average scale number about an inch above the principal point (of the previous example) has increased to about 500,000.

Examination of numerous photographs and consideration of realizable improvements yield strong and well-founded suggestions regarding the kinds of things which might be seen on photographs taken from observation satellites.

Real Thing Best

On the other hand, one is forced to say that calculations, and examination of simulated photographs presumably analogous to those which might be produced by an observation satellite, are at best transient and not-quite-satisfactory substitutes for the real thing.

The area of film which corresponds to a given ground area, at a given scale number, S, is simply film area = ground area/S^2.

If film area is expressed in square feet and ground area in square miles, this formula becomes:

$$\text{Film area (ft}^2\text{)} = \frac{2.8 \times 10^7 \text{ Ground area (mi}^2\text{)}}{S^2}$$

An alternative formulation, for film area to cover a given ground area, at specified ground resolution and film resolution levels (in feet and lines per millimeter) is:

$$\text{Film area (ft}^2\text{)} = \frac{300 \text{ Ground area (mi}^2\text{)}}{R^2 G^2}$$

In general, photography at Levels A or B may be considered for covering many millions of square miles. Coverage of huge areas at Level D would produce truly tremendous quantities of film. Fortunately, any sensible concept of, say, an inspection operation, would involve doing observation at various levels for varying purposes. Huge areas could be covered at Level A, producing interesting areas to be subjected to observation at Level B, etc. Thus successive observations with increasing detail over smaller and smaller areas, through the several levels, may be thought of as constituting an "observation sieve."

To appreciate this point, consider the areas covered at each level, subject to the constraint that an equal area or an equal amount of film will be produced at each level. Suppose, for a given inspection operation, that it is necessary to cover 20,000,000 sq mi at Level A. Then, if the same amount of film is also obtained at each succeeding level, 800,000 sq mi can be covered at Level B, 32,000 sq mi at Level C, and only 1280 sq mi at Level D! (The center values at each level were used in this example.)

The photo on page 27 was taken with a 6-in. lens from a Viking rocket at an altitude of about 150 miles. Resolution is estimated to be about 10 lines per millimeter in the resulting photography, thereby giving a ground resolution of about 500 ft, much poorer than Level A. On the photograph, major railroads show up clearly even with casual observation; two major airfields are easily seen, with runways clear and distinguished; and major streets in a nearby city are fairly easily resolvable and can be plotted. (This examplifies the phenomenon of long lines being more easily detected than small square objects.)

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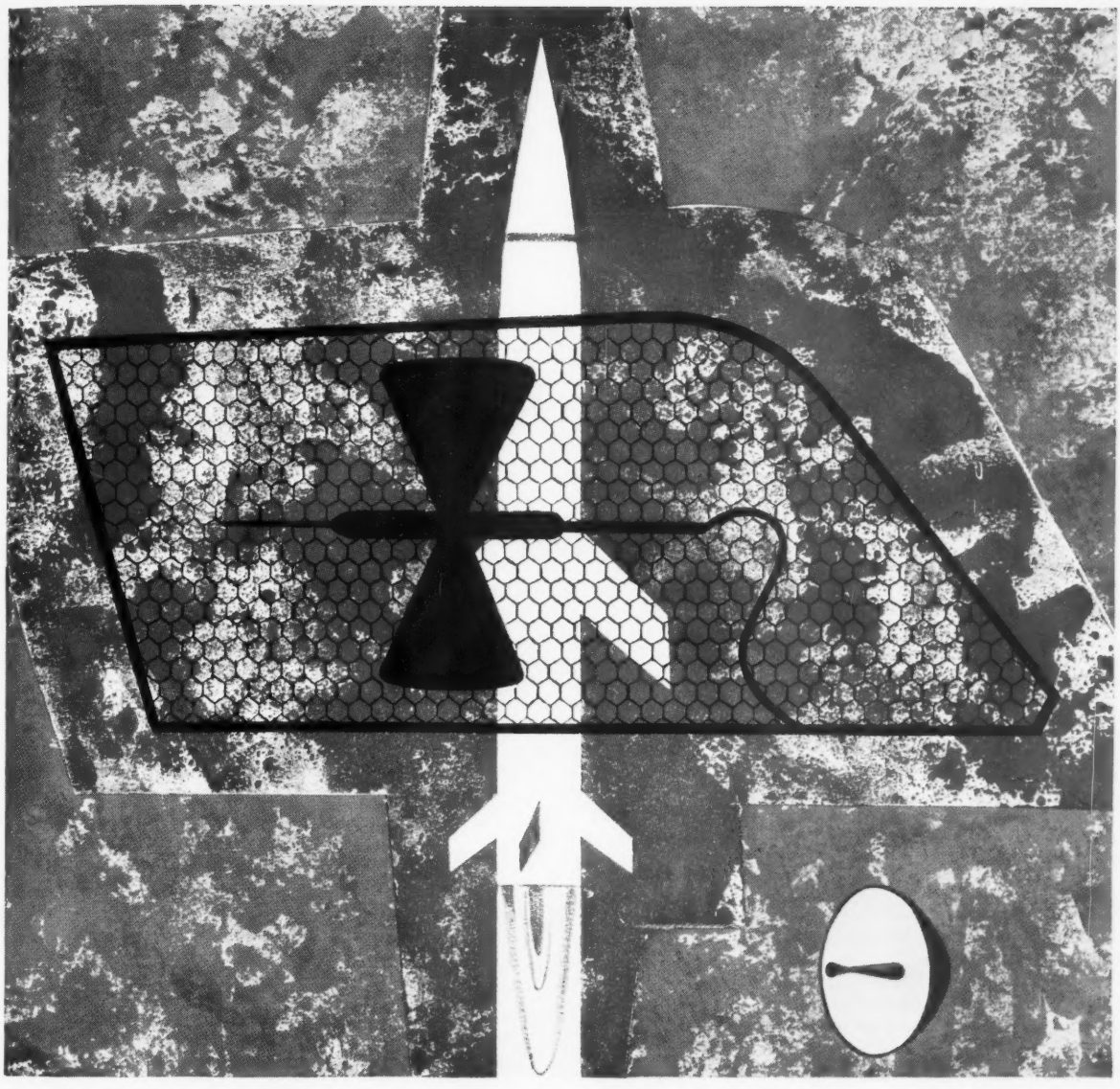
♦♦

Hounddog Ground Support Trailer

This Horkey-Moore trailer, which circulates coolant anhydrous ammonia, has joined the GAM-77 ground support equipment currently being field-tested at Eglin AFB, Fla., and North American's Missile Div. in Downey, Calif.



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People in the news

APPOINTMENTS

President Eisenhower has nominated **Courtland D. Perkins,** chairman of the Dept. of Aeronautical Engineering at Princeton Univ., as Assistant Secretary of the Air Force.

Maj. Gen. August Schomburg has succeeded Maj. Gen. J. B. Medaris (Army-Ret.) as AOMC commander. Gen. Schomburg formerly was deputy chief of ordnance.

William H. Pickering, JPL director announces the appointment of **Brian O. Sparks,** former general manager and acting director of the Space and Missiles Div. at Interstate Electronic Corp., as deputy director. **J. D. McKenney** has been named assistant director of planning; **F. E. Goddard Jr.**, assistant director for NASA relations, Washington, D.C.; **C. I. Cummings**, spacecraft program director, assisted by **J. D. Burke,** deputy; and **R. J. Parks**, Sergeant program director, assisted by **J. N. James,** deputy.

Harold F. Lanier, manager, Goodyear Aircraft Corp.'s Guidance Engineering Dept., has been named special assistant to James Bridges, DOD's Director of Electronics in the Office of the Director of Defense Research and Engineering.

Leslie Silverman has been elected chairman of AEC's Advisory Committee on Reactor Safeguards. Dr. Silverman is professor of engineering in environmental hygiene and director of the radiological hygiene program of Harvard Univ.'s School of Public Health.

H. Thomas Bean, vice-president of Telecomputing Services, Inc., and general manager of its New Mexico Div., has been elected executive committee chairman of the Holloman Test Directors Council at AF Missile Development Center.

Lt. Gen. Donald L. Putt (AF-Ret.), president of United Technology Corp., has been appointed a U.S. delegate to AGARD, along with Theodore von Kármán, who is chairman, and Hugh Dryden, NASA deputy administrator.

Thomas L. Miller, former chief of countermeasures branch at ARDC's Headquarters, has joined Instruments for Industry, Inc., Hicksville, N.Y., as director of systems and programs.

J. Paul Walsh, former deputy director of Project Vanguard and systems manager for special products, IBM's Federal Systems Div., has joined C-E-I-R, Inc., as director of the Space and Weapons Systems Div.

At Aerojet-General, **Gen. O. P. Weyland** (AF-Ret.) has been named a consultant and a member of the Corporate Advisory Board. **William C. House**, previously on a year's leave of absence with ARPA, has been appointed director, systems management, to coordinate the Systems and Space Technology Divisions. In other appointments, **Emerson S. Reichard Jr.** has been named vice-president, administration, Sacramento; and **Elmer E. Nelson,** assistant to president Dan A. Kimball. **John M. Bodley,** former AEC legal aide and Justice Dept. trial attorney, joins Aerojet as a special assistant to Kimball and general manager William E. Zisch.

Gene R. Peterson has been named general manager of GE's Ordnance Dept. He formerly was manager, communications and data handling systems engineering, at the company's Heavy Military Electronics Dept.

The Martin Co. has appointed **William L. Whitson**, former vice-president of engineering, Daystrom, Inc., director of advanced programs, Denver Div. Prior to his work at Daystrom, he was acting chief scientist at ARPA and assistant director at IDA. **Oscar F. Carlson** has been named assistant to the division's general manager.

Hal F. Halsted will head Atlantic Research Corp.'s new Space Vehicles Group, with headquarters at Pasadena, Calif. Senior engineer will be **David Benun**, while **John W. Reed Jr.** and **Joseph Balrush** will be responsible for precontract engineering and administrative functions, respectively. **Charles K. Leeper** is the new director of the Mechanical Engineering Div., Alexandria, Va. Joining Leeper's staff are **A. W. Armstrong, Eugene C. Mooring, Newton F. Spraggins, John L. Lavoie, Henry H. Adams Jr.,** and **John H. Walker.**

John J. Giba has been appointed acting manager of American Bosch Arma Corp.'s Tele-Dynamics Div.

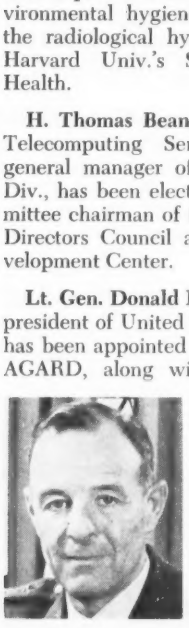
Rocketdyne has appointed **Daniel O. Klute** as chief of Solid Propulsion Systems in the Solid Propulsion Operations at Canoga; **R. R. Morin** as SPO assistant chief engineer; and **D. M. Leitch** as chief of solid propulsion components.

At Douglas Aircraft, **Charles B. Buckley** has been appointed to the new position of assistant to the president-corporate planning and development. **Richard J. Davis,** the company's PR representative in Washington, becomes director of public relations, succeeding vice-president **A. M. Rochlen,** who has retired but continues on as a consultant. **Howard P. Maginniss** will replace Davis.

Neil J. Waterman has been appointed assistant head of STL's Atlas Project Office of Flight Test Operations.

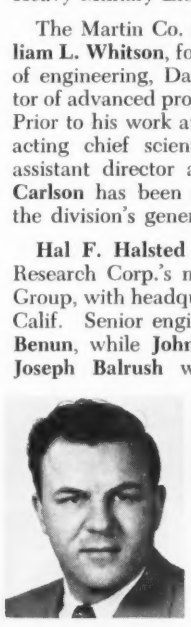
Thompson Ramo Wooldridge has appointed **George C. Kanen Jr.** senior program adviser, Military Dept., for the Dage Television Div. In the Tapco Group, **Ben Barish,** former chief engineer for ground equipment development, has been named head of the new Project Management Dept. **Robert T. Craig** and **Jack J. Reinmann** have been promoted to senior project engineer and project engineer, respectively, in the New Devices Laboratories.

Robert F. Leinicke has joined the R&D technical staff of McCormick Selph Associates as group leader responsible for design and development of cool gas generators.



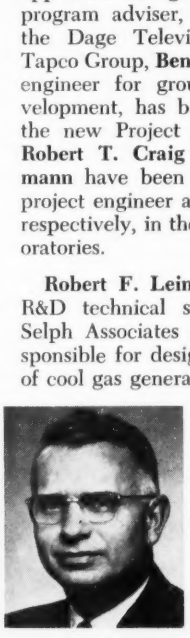
Schomburg

Sparks

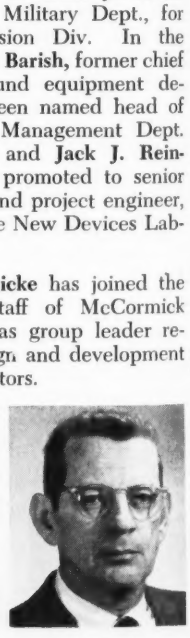


House

Peterson



Whitson



Halsted

Dowell

Coulson

Piore

Turner

Damberg

Elms

Aeronutronic has consolidated its basic research functions into Aeronutronics Research Operations headed by **Lloyd P. Smith** as general operations manager. The following have been named managers in their respective areas: **Arthur J. Ruhlig,** physics and computing; **Cravens L. Wanlass,** solid state devices; **Leon Green,** acting, aerothermochemistry and materials; and **Lawrence Kavanau,** planning. **Montgomery H. Johnson,** general operations manager, Space Technology Operations, has been promoted to senior staff scientist. **Donal Duncan,** assistant general operations manager, succeeds Johnson, while **Charles G. Gant** moves up into Duncan's former post.

Texas Instruments has announced that **K. P. Dowell** will direct the new Radar Department in the Apparatus Div., and will devote full time to ASW activities. **A. L. Coulson** assumes Dowell's former post as manager of the division's Service Engineering Dept.

Emanuel R. Piore, IBM director of research, has been named chairman of the company's Research and Development Board. **Leo Esaki,** discoverer of the Esaki diode, has joined IBM as a resident consultant. **William J. Lawless Jr.** has been upped from executive assistant to the IBM executive vice-president to director of system and application engineering.

Warren P. Turner has been named product manager, military products and solid propellants, for the Energy Div. of Olin Mathieson Chemical Corp.

Vincent J. Cushing, former director, Fairchild Applied Science Div. of Fairchild Engine and Airplane Corp., has been appointed president of the newly formed Applied Science, Inc., Alexandria, Va., offering research and analytical services for government and industry. **Frank Genevese,** former manager of operations research of the Fairchild Div., is vice-president.

Louis Bruchiss, former editor of the *Journal of the American Rocket Society,* heads Technical Intelligence International, set up to serve industry on high-level writing projects.

Robert A. Bass has been named chief scientist for Aeronca Mfg. Corp.'s Aerospace Div., Baltimore, to direct celestial mechanics and space-vehicle orbit research.

Carl F. Damberg has been named general manager of Republic Aviation's Missile Systems Div.

David William Moore, manager of Servomechanisms, Inc., Applied Research Laboratory, has joined Lear, Inc., as manager of the solid-state physics laboratory.

James C. Elms, vice-president of ground electronics and communications, Avco Corp.'s Crosley Div., has been upped to vice-president and general manager of defense operations for the division.

John M. Thompson has resigned as chief of test facilities laboratory at Rome Air Development Center to become vice-president and general manager of Itemlab, Inc., Port Washington, N. Y.

Albert H. Bryan Jr. has been named manager of advanced development for Raytheon's Missile Systems Div. He formerly was chief, research and engineering for ARGMA'S R&D Div.

Lawrence F. Boland has been elevated from vice-president to executive vice-president of The Beryllium Corp.

Carl T. Lenk and **David J. Craig** have been promoted to managers, chemical research and propellant research, respectively, in the Contract Research Dept., Wyandotte Chemical Corp.

Hugh M. Williams, director of Link Div.-Palo Alto of General Precision, Inc., has been elected vice-president of the division. **William W. Wood Jr.,** former vice-president, simulator engineering, has been made a director of GPI and executive vice-president of Link. **Edward Sheridan** joins Link as director of eastern laboratories.

Food Machinery and Chemical Corp. has appointed **Ralph Bloom Jr.,** Washington, D.C., representative for the Chemical Div., replacing **Philip H. Groggins,** who becomes senior scientific adviser.

Roy H. Lynn has been appointed president of ITT Communication Systems Inc., and **B. R. Stack** has been promoted from project engineer to manager of military projects, ITT Laboratories.

Daniel E. Murphy becomes director of Consolidated Electrodynamics Corp.'s Datalab Div., and **Kenneth W. Gardiner,** chief research chemist of CEC.

William M. Shine has been appointed vice-president of Celanese Development Co., and **Howard S. Malby,** head of field technical service, Celanese Plastics Co., both divisions of Celanese Corp. of America.

Barnes V. Dale, manager of modules engineering at RCA has been upped to manager, Micromodule Dept.

Rushmore H. Mariner has been named general manager of the New Products Div. of Corning Glass Works. The new Ceramic Dept. will be headed by **Philip C. Leffel Jr.**

Jack H. Frailey, former manager of missile systems, RCA's Missile Electronics and Control Div., has joined Itek Corp. as executive assistant to the general manager.

Augustus B. Kinzel, vice-president, research, Union Carbide Corp. has been elected 1960 president of the Engineers Joint Council.

Lawrence W. Von Tersch, head of Michigan State Univ.'s Electrical Engineering Dept. has been elected 1960 president of the National Electronics Conference.

Standard Steel Corp. has named vice-president **James E. Cox** as general manager of its Cambridge Div. in Lowell, Mass.

John F. Price has been appointed engineering manager for the West Coast Div. of Military Electronic Operations of Allen B. Du Mont Laboratories, Inc. He previously was en-

gineering supervisor of special tests and instrumentation for NAA's Missile Div.

Murray Bloom has joined Pacific Semiconductors, Inc., where he will do semiconductor surface research studies.

George A. Peck has been appointed president of Southwestern Industrial Electronics Co.

Sidney Gerhard has been named chief engineer, Propulsion Test Facilities, a division of MB Electronics.

John J. Carpenter has been elected a vice-president of Bulova Watch Co., Inc., and named general manager of its new Industrial and Defense Div.

Clyde Skeen has been made executive vice-president and general manager of Temco Aircraft Corp.

Oskar E. Mattiat has been appointed chief scientist of Acoustica Associates, Inc.

John C. Williams Jr. has been promoted to vice-president of Compu-Dyne Corp.'s Weighing & Control Components Div.

George Anisman becomes research and product planning manager of Telecomputing Corp.'s Whittaker Controls Div.

Thomas

Bordeaux

Electronic Specialty Co. has appointed **James A. Marsh** corporate vice-president, engineering.

William J. Suchors becomes coordinating director of engineering and product planning for Remington Rand Univac Div. of Sperry Rand Corp.

Jay Tol Thomas has been appointed director of engineering for the Boston Div. of Minneapolis-Honeywell Regulator Co., where he will supervise its R&D programs.

John J. Bordeaux, former senior research scientist in the electrochemistry and solid-state chemistry section of the Missile and Space Division, Lockheed Aircraft, has joined Rheem Semiconductor Corp.'s R&D team.

E. Kent Reese has been appointed vice-president and general manager of National Rocket Corp., Palo Alto Div.

Max D. Liston will direct Beckman Instruments newly formed Special Products Div.

Harold W. Giesecke has been appointed manager of Hydro-Aire Co.'s new Electronics Dept.

At General Motors, **Harold H. Dice** has been elected a vice-president and appointed general manager of the Allison Div., succeeding **Edward B. Newill,** who has retired.

HONORS

Chao C. Wang, Sperry Gyroscope Co. electronics scientist, has received the Victor Emanuel Distinguished Professorship at Cornell Univ. for Spring 1960 term. The award, sponsored by Avco Mfg. Co., is given to "persons of broad technical competence whose interests extend into many fields of science and engineering." ♦♦

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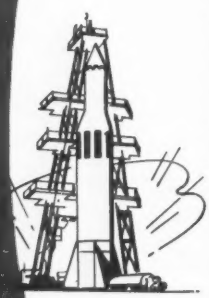

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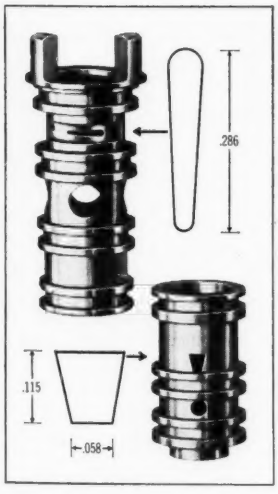

As a subcontractor, CECO is equipped to handle specifications demanding production tolerances to 5 millionths of an inch and finishes to .5 RMS. Most of the servomechanism system components shown above were manufactured to just such specifications.

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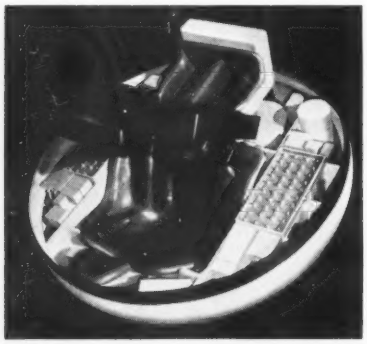
White Algae For Space Food

Arthur J. Pilgrim, left, Boeing's biochemistry unit chief, and Gerald Christensen, biochemist, both of the company's Space Medicine Section, check the growth rate of a batch of algae. The child's wading pool was selected as the least expensive container of its size and shape suitable for the farm.

Scientists of Boeing's Space Medicine Section have been experimenting with various ways of growing algae during the past several months. By blanching disagreeable-tasting green algae under fluorescent lights, they have finally been able to produce a palatable white algae which looks much like flour, is nutritious, and can be used in making cookies or cupcakes. White algae also can be prepared in paste form—very possibly a necessity for its practical case in space.

Prototype Representation Of MMSS Biocapsule



According to American Latex Products Corp., which makes the form-fitting urethane-foam couch, this is a prototype representation of a manned maneuverable space capsule under development by Norair Div. of Northrop. The foam of the couch is coated with a film of flexible plastic.

R&D Proposal

(CONTINUED FROM PAGE 39)

The answers to these questions will help us in our operation and will also assist the Government in its job of trying to get the most for its money within the statutes and regulations that affect Government procurement.

In deciding whether or not to submit a proposal, management would do well to indulge in a bit of objective soul searching. It would be wise to ask, "Are we uniquely qualified or particularly competent in this field?" Even if the answer is no, we might ask "Are we at least as well technically qualified as anyone else?" Finally, we should ask ourselves, "Would it make sense for the Government to give us a contract for this work?"

If a company is certain it is uniquely qualified to tackle a problem, it is in a position to write a highly acceptable, and probably winning, proposal. This might be considered one of the rules of thumb for any proposal: If you can demonstrate uniqueness by virtue of personnel, proprietary techniques, patents, or facilities—spell it out. It all adds up to being able to offer the Government the most economical answer to its problem.

In evaluating relative technical competence, it is worthwhile bearing in mind that the Government does not consider prior experience in a particular field as the criterion for determining technical competence. In many cases, experience in a totally different field can be related to a new problem. One advantage to this is that it may very likely bring a fresh approach to a problem, and may offer more chance of success than other techniques that have previously failed.

The question as to whether it would make sense for the Government to award a contract to a particular firm has several ramifications. Not infrequently, companies are anxious to get into an entirely new area in order to diversify their activities. Considerable effort may then go into a proposal in vain, for unless the company can demonstrate that its activities in another field are applicable to the problem at hand, the chances are good that the proposal will not be accepted. Fortunately, our present procurement system prevents this from developing often. Proposals are solicited only from those organizations known to be qualified in the field by past experience either directly or indirectly. Insofar as R&D is concerned, it might be worth mentioning that the Government is not normally in the role of assisting industrial organizations to diversify their activities.

These, then, are some of the factors that must be weighed before deciding to submit a proposal. Once this decision is made, a schedule should be established, and a team organized to prepare the proposal. Without organization, proposal preparation can readily develop into a nightmare of feverish activity.

The first step probably should be a briefing for all personnel concerned. This is particularly desirable in the case of large proposals. At this briefing, the schedule is reviewed, the problem discussed, and responsibilities assigned. A more detailed technical discussion should probably follow, in the course of which the scope of the problem is clearly defined and various appoaches considered.

The first, or general, briefing will help to orient everyone concerned and will alert cost and contract administration personnel to any particular problems that will require their attention early in the game. The technical briefing will help steer the proposal in the right direction from the beginning. It will also help to ascertain that the problem is clearly understood and that sufficient information is on hand to write the proposal.

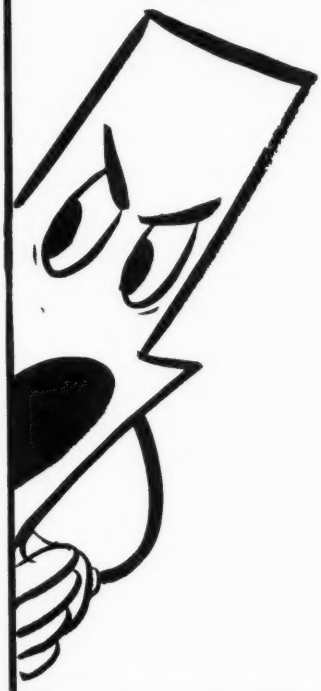
Bidders' Conference Invaluable

On occasion, invitations to submit proposals specify that a bidders' conference will be held before the date proposals are due. Such meetings are invaluable in orienting bidders who have been out of touch with either the contracting agency or its problems for any length of time. They also serve to clarify and expand the usually terse description of the problem in the invitation. Finally, they provide an opportunity for bidders to ask specific questions.

If an organization plans to bid on a program, it would certainly be well-advised to attend any bidders' conference held. If there is doubt as to the wisdom of bidding, a bidders' conference may very well provide answers that will settle the questions. It goes without saying that such a conference also offers intelligence, both in terms of quantity and quality, as to the competition involved. In some cases, even though a decision has been made *not* to bid, experience has shown that it may be worthwhile to attend the conference.

We recently received an invitation to bid which appeared somewhat off our track, and a tentative decision was made not to bid, pending the results of the bidders' conference. Frankly, there were enough areas in the invitation to intrigue us, and this also played a part in our decision to attend the

I'm a Frustrated Flaw. Normally I'm Invisible.



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conference. At the conference, we learned enough to know that we did not wish to bid, but we also learned of two new applications for our research effort, and learned further that this particular agency had recently been assigned a mission that could well result in a need for our services that we had not previously realized.

By the time a bidders' conference has been concluded, sufficient understanding of the problem should be on hand to permit preparation of the proposal. In some cases, if additional questions arise, technical personnel may be contacted directly. In other cases, where the Government feels such contact may offer unfair advantage to one bidder over others, specific and pertinent questions will be answered by the technical personnel *through* the procurement office.

In organizing a proposal, several considerations should be kept in mind. First, as with any technical document exceeding 5 or 10 pages, a summary is desirable. This permits the sense of the proposal to be gathered at once, and helps orient the reader.

Following the summary, an introduction may be desirable, depending upon the circumstances. Basically, an introduction is intended to orient the reader, acquaint him with the problem, and lead him into the body of the proposal. If the summary has already done this, it hardly seems worthwhile to repeat the entire message solely for the sake of having an introduction.

In some cases, the introduction is a logical place to present additional information that will help justify the approach you have selected. This may take the form of information regarding some unique process or technique you have developed which will be particularly well-suited to the problem, or a brief explanation of the potential your proposal offers for other problems facing the agency. In either case, the intent is the same—to offer evidence supporting the proposal.

The next major portion of the proposal is usually the statement of the problem. The intent of this section is to demonstrate your understanding of the problem. In many respects, it is one of the most difficult sections to prepare because it should present enough information to demonstrate that you appreciate the subtleties of the problem without going into a prolonged technical analysis. Save your strength for solving the problem. Remember that the proposal is intended to demonstrate how you would go about solving the problem, not your ability to restate the Government's problem.

In rare cases, the statement of the problem may justifiably require supporting information, such as a historical background or a summary of the present state of the art. To avoid cluttering up the proposal, it may be well to extract the pertinent facts of such sections and relegate the details to an appendix.

Heart of Proposal

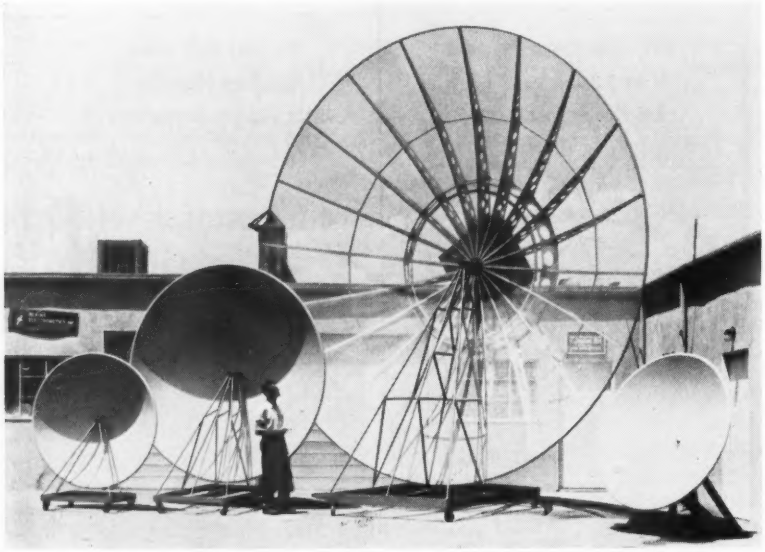
Once the problem has been stated, the proposed approach to the problem should be given. In many respects, this is the heart of the proposal, for it is the section that usually receives paramount attention. A well-stated understanding of the problem, the best facilities, the most talented personnel, and all of the other advantages that a contractor can offer, may well be unimportant if he does not offer a logical and promising approach.

The makeup and organization of the team proposed for the work should be spelled out; and again, in order to keep the proposal uncluttered, résumés of the team members should be given in an appendix. Some contractors choose the present résumés of many people in addition to those who will be engaged on the program. To the extent that such résumés indicate the attributes of personnel who will make supervisory or tangential contributions to the program, this may be worthwhile. On the other hand, résumés of people who by their title or position do not appear even remotely connected with the program could very well be construed as padding.

In some programs, the work proposed may be scheduled in several phases or work units. If so, it is desirable to present a section entitled "schedule," in which the work is displayed along the projected period of performance. For convenience and clarity's sake, a simple bar graph may prove effective.

In many instances, it may be worthwhile to include a section on "specific qualifications." This is a useful means for presenting information on past or concurrent efforts that have specific bearing on the proposed program. In particular, specific contracts in related fields should be mentioned. This section may make reference to facilities or other company experience presented in an appendix.

Finally, the body of the proposal should contain a firm contractual statement summarizing the scope of work and offering to do it for a certain sum and within a certain time. A detailed



Precision Laboratory Transmitting Antennas

This array of precision laboratory transmitting antennas, designed and built by Blaine Electronics of Van Nuys, Calif., constitutes some of the advanced equipment for space communication studies at Douglas Aircraft's Antenna Pattern Measurement Range of the El Segundo Div. The reflectors are excited by balum dipole feeds, which are interchangeable in sets. These devices provide Douglas with the ability to work in small sizes of equipment over a wide frequency range, from 100 to over 12,000 mc.

cost breakdown can be relegated to an appendix.

A word of caution may be in order here. In some instances, the invitation to bid may specify that two proposals are desired—technical and cost proposals. If so, the cost portion of the statement of work can be modified to read "in accordance with the attached cost proposal."

Beyond the body of the proposal come the various appendices referred to in the proposal. Even if having only general reference in the body of the proposal, any information or photographs that will demonstrate your ability to undertake the work should be presented.

In one case not so long ago, we submitted a proposal, and eventually learned that one of the major factors resulting in our being selected was some incidental information presented in an appendix. Part of the problem involved analytical work in a highly specialized field, and the agency's technical personnel placed more importance on this than we appreciated. Therefore, the body of our proposal dealt heavily with the technical portions we considered important, and placed little emphasis on the analytical work. However, in an appendix, we briefly described some of our current contracts, one of which involved analytical work closely related to the type apt to be encountered in the program. When all factors were considered, we came out on top.

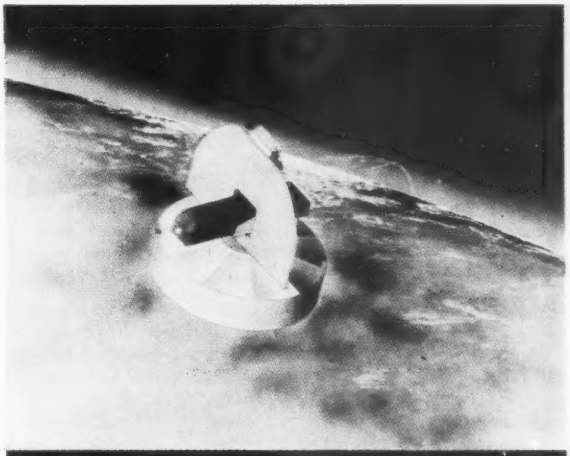
Perhaps it would be well at this point to look to the source of the various policies and practices that govern proposal evaluation.

DOD procurement practices are governed by the Armed Services Procurement Regulations, and the basic rule for evaluating R&D proposals is spelled out in these regulations. The exact words are: "The contract shall be awarded to that responsible bidder, whose bid, conforming to the Invitation to Bid, will be most advantageous to the Government, price and other factors considered."

What It Means

This statement deserves careful study, because virtually every word conveys more meaning than might appear at first glance. As a first step, let us take a look at what the Government means by "responsible bidder." A responsible bidder is "one who is a manufacturer or a regular dealer and is financially and otherwise able to perform the contract, and is otherwise qualified and eligible by law."

Most bidders will qualify as manufacturers or regular dealers in the broadly accepted definition, and there-



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fore we can turn our attention to the words "financially and otherwise able to perform the contract." Financial ability can be demonstrated by a healthy balance sheet; and since R&D contracts frequently make provisions for monthly progress payments, even this is not too critical. On the other hand, a company obviously on the financial ropes may have some difficulties here.

What Creates Doubt

The words "and otherwise able" cover a multitude of sins, and with good reason. If a contractor has not adhered to schedules, even on a matter as simple as progress reports, his abilities are somewhat in doubt. This is where a previous record of efficient contract performance is valuable.

Even if previous contracts did not result in any significant developments, the general manner in which the contract was handled both technically and administratively is important.

Incidentally, in at least one agency, evaluators are required to take into account a bidder's "overrun" history, i.e., how many times he has had cost overruns on his R&D contracts. In short, the Government considers the number of contracts a bidder has had, the frequency and quantity of his overruns, and any extenuating circumstances that may have affected these overruns. If a contractor overruns chronically, it then leads to some doubt as to either the validity of his cost estimates or his cost-control operations. In either case, it will not help his current proposal.

The next item worth noting is the phrase "whose bid, conforming to the Invitation to Bid." This is one area where a bid may be lost without the bidder realizing his error. The basic reason for soliciting proposals is to allow industrial organizations to compete for work on a common basis—the invitation. If a bidder elects to submit a proposal that does not conform to the request, he is changing this basis, and his proposal cannot be properly compared with the others.

One area where bidders frequently run afoul of the "conforming" requirement is deviation from the request. For example, a bidder may hear of a proposed request from a technical man in a Government agency. If the invitation subsequently received does not match the knowledge he gained at the agency, he is apt to bid on what he heard, rather than what is spelled out in the invitation. He may never realize that the original request was modified in the light of other needs of the agency before issuance of invitations, until he learns that the contract for the work, as requested, was awarded elsewhere.

It is probably worth pointing out that the Invitation to Bid contains many specific instructions (in addition to the technical statement of work) which must be followed to assure conformity. The proposal due-date is specified, and failure to submit the proposal by that date is adequate basis for rejection. A proposal for a period of performance other than that requested is a deviation. Alternate proposals, unless permitted, may result in a rejection of both bids. A bid for a portion of the work requested will usually be considered nonresponsive. Failure to submit all the data required in the form requested may well jeopardize a bid. The requirements on the invitation aim to put everyone on an even basis, and odd man is usually out.

The final words of the award policy, "will be most advantageous to the Government, price and other factors considered," are perhaps the most sweeping.

What Really Counts

The phrase "advantageous to the Government" obviously covers many things. The item of primary importance, however, is the technical superiority of the proposal. All the résumés, annual reports, leatherbound covers, and three-color overlays in a proposal cannot be expected to sway the evaluator's opinion of the technical presentation.

The bidder must demonstrate (1) that he understands the problem fully and (2) that he has a well thought-out approach which shows signs of promise if executed as described.

On many occasions, proposals have been rejected as a result of bidders underrating the importance of technical superiority of a proposal. In any proposal, revolutionary ideas that offer the possibility of significant scientific breakthroughs are attractive. However, even old, well-established approaches have won contracts. This is particularly true where the reasons for previous failure of these approaches are analyzed, and it is shown that there

Piggyback Payload

The pictured base of a re-entry vehicle prepared by GE's Missile and Space Vehicle Dept. carries examples of the piggyback research instruments described by Lt. Col. Gene M. DeGiacomo (USAF) of AFCRC in the May 1959 *Astronautics*.

Launched recently from Cape Canaveral by a Thor booster, the re-entry vehicle packed a micrometeorite detector, shown being pointed to by its designer, Joseph Frissora, of Geo-Sciences Inc., Alamogordo, N.M., and gauges for measuring both atmospheric ion density and the charge of the vehicle. The gauges extend from the vehicle on arms, as shown, after it leaves the denser atmosphere. The micrometeorite detector contains a membrane that releases a certain amount of gas when punctured. This amount allows an estimate of the micrometeorite size.

The vehicle was one of a series being flown for AFCRC on a noninterference basis in BMD missile tests.

Joseph Frissora points to his micrometeorite detector on the base of a GE re-entry vehicle launched later by a Thor. Data was telemetered.

are still areas in such approaches that have not been adequately investigated.

A clear understanding of the ultimate needs of the Government agency will also assist the bidder in proposing attractive approaches. If the proposal involves the development of a material that will be used in large quantities, then what will be the effect of an approach based on material in very short supply? In many instances, the availability of material will have a decided effect on a given approach. Similarly, if a bidder has done his homework properly, he may find that the agency itself has done some work on the approach the bidder has in mind, and may have some very definite ideas about it.

Technical Evaluation

In some agencies, technical evaluation of the proposal is performed on the basis of the technical portion of the proposal alone; cost information is deliberately denied to the technical evaluator to prevent this from influencing his decision. He is asked to rate the proposals in two broad classes, acceptable and unacceptable. He is required to state reasons for unacceptability, and to rate the others in order of acceptability, with reasons for this ranking. Only then is the cost data brought into the picture.

It is very unusual when the lowest bidder is also the bidder rated highest by the technical personnel. As to bidders who are considered unacceptable in the technical evaluation, cost data is unimportant. Bids are rejected on a technical basis, and even a one-dollar bid would not get a contract. In the case of technically acceptable bids, cost can play a part. In one agency, if any bid other than the lowest priced technically acceptable bid is accepted, justification must be given for rejection of lower bids.

It is significant—and a credit to the agencies faced with the difficult task of evaluating proposals—that contracts are often awarded to a bidder who does not have the lowest price. For example, if two bidders offer similar acceptable technical proposals, but the bidder with the higher price has had specific pertinent experience, this in itself may justify spending the extra money. It is entirely reasonable to argue that the Government would otherwise have to spend this money to orient the lower bidder to the problem.

When all the advantages and disadvantages of bids have been weighed, then, and only then, is the decision made as to which bid is "most advantageous to the Government, price and other factors considered." ♦♦

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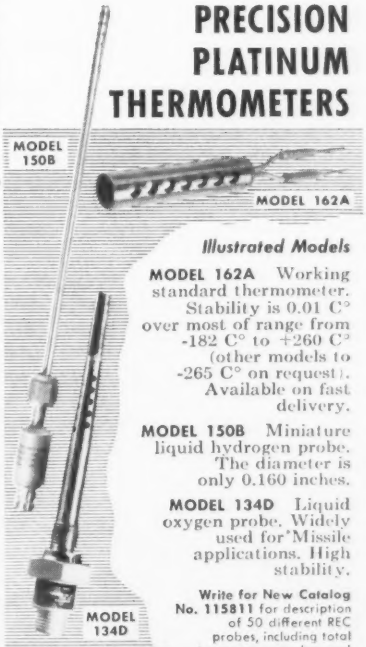

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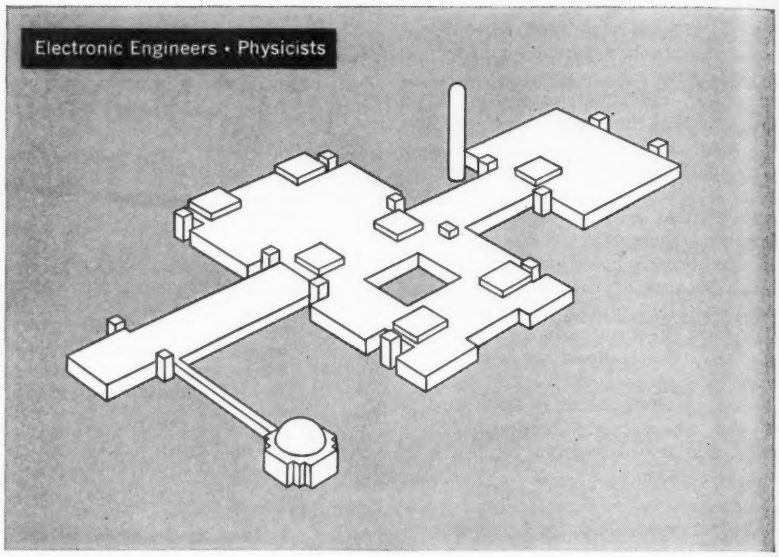
Composition of Outer Space

(CONTINUED FROM PAGE 31)

is filled with the earth's magnetic field and atmosphere, is formed in the solar wind. At the same time, the geomagnetic field is severely deformed by the solar wind. A schematic representation of the cavity and the deformed geomagnetic field is shown in the drawing at the top of page 31. The shape shown is only approximate, as an accurate calculation is very difficult and has not been made. The size of the cavity, and perhaps its shape also, must be expected to change with the strength of the solar wind and hence with the level of solar activity.

The boundary of the cavity is also the boundary of the earth's atmosphere. Outside the cavity, the gas is principally of solar origin; inside the cavity, it is of telluric origin. The boundary must be expected to be turbulent. Hydromagnetic waves, which cause the generally present noise on magnetic records, originate at this boundary. Under normal solar wind conditions, the boundary of the magnetic field in the direction facing the sun is about 6 earth radii from the center of the earth. The widest portion of the magnetic field is more than 12 earth radii in width and may be over 18. This widest portion must lie somewhat downwind from the earth. The length of the tail is most in question, as the length depends upon the temperature or random thermal motion of the particles in the solar wind, which is not known.

The oxygen and nitrogen of the earth's atmosphere become dissociated in the ionosphere. At the base of the exosphere, which is the level above which collisions between gas particles can generally be neglected, or about 550 km, the gas particles are principally atomic oxygen and atomic nitrogen. Although the relative concentrations are not known, it is thought that atomic oxygen is more plentiful than atomic nitrogen by a considerable factor. In addition, there is a small amount of atomic hydrogen present at this level. Although the oxygen and nitrogen concentrations at the base of the exosphere greatly exceed the concentration of atomic hydrogen, the oxygen and nitrogen concentrations fall off rapidly with altitude while the hydrogen concentration does not, as shown in the upper left graph on page 31, so that atomic hydrogen predominates above 1300 km (Johnson and Fish, 1960). The concentration of hydrogen as a function of distance from the earth at greater distances is shown at right. At 7 earth radii, the concentration is only about 10



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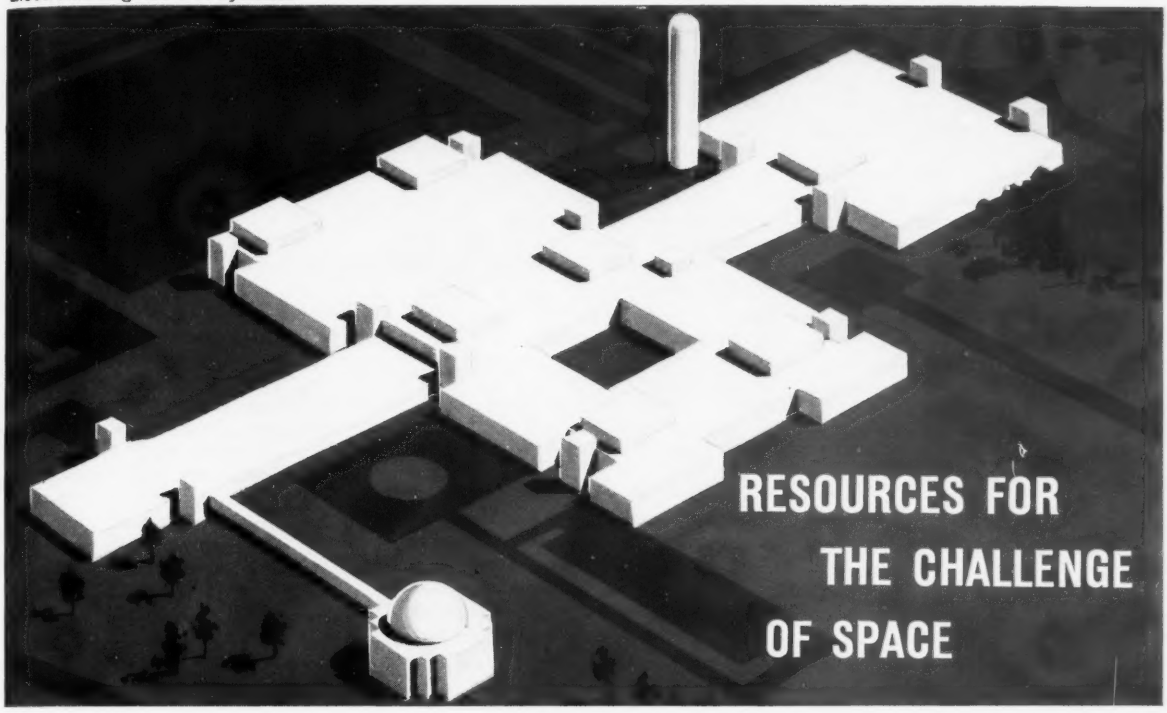

...General Electric's New $14,000,000 Space Research Center, to be built near Valley Forge Park 17 miles from Philadelphia

General Electric is carrying its tradition of pace-setting electronics research into the field of space vehicle applications, primarily through the agency of its Missile and Space Vehicle Department.

Qualified engineers interested in working in these areas are invited to review the opportunities described on *this and the opposite page.* Those who join us will work in a professional atmosphere with other highly trained and competent people who have taken part in such G-E achievements as the FIRST demonstration of effective space vehicle stabilization control and navigation, and the FIRST measurements in space of earth's magnetic field and infrared radiation.

Upon completion of the Department's *Space Research Center* in suburban Valley Forge, new and unique facilities will be available to our staff, to further long range programs in space electronics.

ENGINEER-TRANSISTOR CIRCUIT DESIGN

BS, EE or Physics with advanced degree desired. Five years' experience in circuit design, information theory and circuit philosophy.

ENGINEER-TELEMETRY DESIGN

Will design and evaluate airborne and ground telemetry, voice and video circuits and components. Thorough knowledge of both transmitter and receiver design, five years' experience; BS, EE required.

DIGITAL CIRCUIT DESIGN

To provide high level technical evaluation of digital techniques as applied to airborne digital and pulse circuitry, EE with five years' experience in this field.

ENGINEER-CONTROLS

Will be responsible for analytical studies in adapted controls, non linear systems and analogue and digital computation. Requires ten years of controls background with BS, EE or related degree.

ENGINEER-DYNAMICS

To conduct analytical studies in the dynamics of rigid bodies as applicable to navigation and control systems. Requires eight years of experience with MS degree in mechanics or physics.

ENGINEER-SYSTEMS ANALYSIS

Requires eight to ten years experience in analytical studies of complex systems, with some control experience. Background in analogue and digital equipment also desirable.

Check additional openings listed to the left, and write to Mr. Thomas H. Sebring, Div. 11MD.

MISSILE & SPACE VEHICLE DEPARTMENT

GENERAL ELECTRIC

3198 Chestnut Street, Philadelphia 4, Pa.

atom per cc and, beyond this distance, the concentration falls approximately according to the inverse square of the distance from the earth.

The temperature of this corona of hydrogen around the earth is the same as the atmospheric temperature at the base of the exosphere, or about 1250 K as determined from the rate of orbital decay of the Vanguard satellite, 1958 β 2 (Harris and Jastrow, 1959). At these altitudes, where the gas densities are very low, temperature has a meaning only in describing the velocity distribution of the gas particles, as the rate of heat transfer from the gas particles to a solid body such as a satellite is negligibly small compared with the radiative heat flux through the region.

The concentration of ions near the base of the exosphere is shown in the lower left graph on page 31. The principal ion near the maximum of the ionospheric F-2 region is O^+ and its concentration with altitude is shown in the graph (Johnson, 1960). The oxygen ions react with atomic hydrogen in the atmosphere principally near the base of the exosphere at 550 km and provide a source of atmospheric protons. The protons above the base of the exosphere are distributed according to a diffusive equilibrium, as shown in the graph. These protons, along with an equal number of electrons for electrical neutrality, constitute the protonosphere, which is the extreme extension of the ionosphere responsible for the propagation of radio whistlers.

Key Temperatures

The protons and electrons in the protonosphere are characterized by the same temperature as the base of the exosphere, or 1250 K. At higher altitudes, the diffusive equilibrium distribution of protons, shown in the lower right graph on page 31, is influenced by the rotation of the earth in the presence of the geomagnetic field. This distribution extends out roughly to the limit of the magnetic field on the daytime side of the earth. On the night-time side, the distribution should be the same as shown in this graph out to a distance of about 6 earth radii. Beyond this distance on the night-time side of the earth, the tail of the magnetic field should also be filled with protons and electrons of telluric origin, but there is no basis at present for estimating the concentration.

This region beyond about 6 earth radii on the night-time side of the earth is coupled by means of the magnetic field to the ionosphere within the auroral zones of the earth. The protons and electrons within those magnetic field lines which intersect the earth's surface at magnetic latitudes below about 65 deg must rotate with the earth, whereas the protons and electrons within those magnetic field lines which intersect the earth's surface above about 65 deg, i.e., those in the tail of the top figure of page 31 and extending around into the polar ionosphere, do not rotate with the earth, although some twisting distortion of the field and plasma must occur there. Hines (1959) has already commented on the possibility that the magnetic field in the polar region may not rotate with the earth.

In addition to the atmospheric particles discussed above, both neutral and ionized, there are a few high-energy particles to be considered. The geomagnetic field contains trapped particles which constitute the Van Allen radiation. Compared to the particles already described, the trapped high-energy particles are few in number. The trapped particles consist of something on the order of 10^{-6} proton per cc with energies up to 700 mev, but with a most probable energy of a few mev, in the inner zone of the Van Allen radiation belt. There are also about 10^{-4} electron per cc in the inner zone and 10^{-2} electron per cc in the outer zone with energies below 800 kev and with the peak of the energy spectrum falling near 100 kev. All of these energy values are considerably in doubt at this time, as too few measurements have been made to establish reliable limits.

Other high-energy particles contributing slightly to the numbers of particles in space are the cosmic rays and the solar flare protons. The cosmic rays amount to about 10^{-10} particle per cc with energies generally greater than 10^9 ev. In the vicinity of the solar system and following certain solar flares, the number of energetic particles may increase considerably due to the ejection of solar flare protons with energies of the order of 100 mev and concentrations of the order of 10^{-6} to 10^{-8} proton per cc. When these events occur, the solar-flare protons remain in the solar system for a few days before they become lost to interstellar space.

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Room with a View

Through prompting by the Astronauts themselves, out of the cramped quarters of the Mercury capsule now opens a picture window. Developed by Corning Glass, the window, which can be seen above on a McDonnell prototype, consists of four spaced panes of high-strength, high-temperature glass designed to withstand the sames stresses as the metal walls of the capsule and precision-finished to give high optical quality. The Astronaut can determine capsule attitude as well as take pictures through the window.

Reliability Research

The National Bureau of Standards is engaged in probability and statistical studies basic to the prediction of system reliability. The long-range goal of this program is to make available a spectrum of approaches to model construction and a variety of statistical techniques and criteria for selecting the most suitable method for a particular application. Its results will apply to electronic computers, weapons systems, and other complex equipment.

From the patent office

By George F. McLaughlin

Split Ring Jet Vanes Steer Missiles

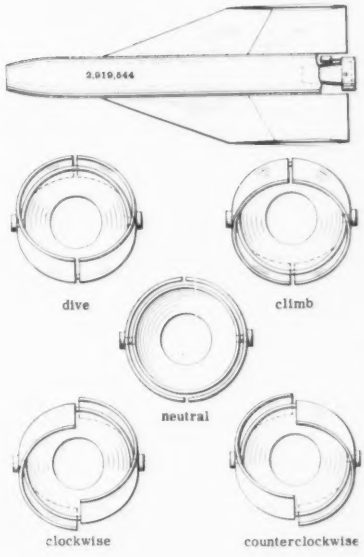
High speeds imparted to guided missiles have necessitated design of controls that minimize drag. Such a new type of control recently patented uses a jet vane constructed of a split sleeve or ring circumscribing the jet discharge nozzle. Movable ring segments deflect the jet stream—each segment pivots on trunnions to permit corresponding ends of segments to be moved into the jet stream in the same direction, or in opposite directions, to produce a differential action.

Steering sectors may be laterally positioned either to the interior or exterior surface of the discharge nozzle. Width of sectors depends upon individual design considerations. Sectors can be identical in construction, thereby lowering their cost.

The nozzle is tapered to receive the inactive end of the sector as the opposite deflecting end is swung into the jet stream. Minimum clearance throughout the arc of movement is also maintained by positioning each trunnion forward of the vertical centerline. An important steering feature is a "fail-safe" safeguard which returns to neutral if the actuating mechanism fails.

Numerous combinations of movements necessary to steer the missile (or aircraft) in the desired direction are readily obtainable.

Patent No. 2,919,544. Steering Mechanism for Jet Propelled Craft. E. Quimby Smith Jr. and Lyle E. Matthews, Oxnard, Calif., assignors to the U.S. Navy.



At top right, plan view of missile, partly in section, depicts steering mechanism. Below, rear views of split rings in various attitudes.

Space-Efficient Pump System

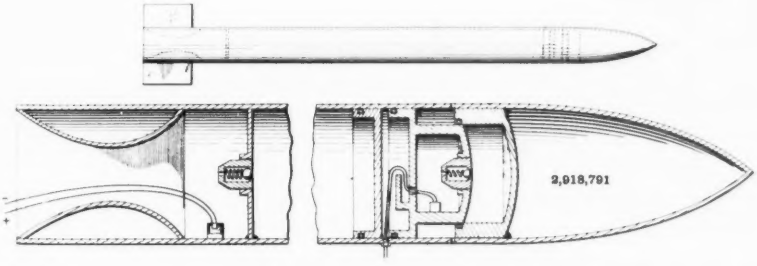
Complicated fluid pumping and gas storage at high pressures are uniquely eliminated in a patented system supplying fuel in reaction motors. An igniter which may be comprised of a small charge of black powder, or small solid grain, electrically ignited, initiates combustion when nonspontaneously ignitable fuels are used.

In this system, a fluid-containing chamber and a pressure-generating chamber are separated by a movable partition. A differential-area piston transmits pressure from the latter chamber to the gas generator chamber, effecting injection of the gas generate into the pressure generating chamber. The casing has openings communicating with the space between the outer surface of the piston wall and the inner surface of the casing, thus preventing entrapment of air in the space upon forward motion of the piston.

Where the liquid or the gas generant in the chamber is ethylene oxide, it has been found that from about 30–35 cu ft of gas at standard conditions is obtained from as little as 2 lb of gas generant in the chamber. Only a small area of the missile is required for efficient and smooth pumping of the primary propulsion fuel into the combustion chamber.

A chamber at the forward end of the missile may contain instruments or an explosive charge.

Patent No. 2,918,791. Differential-Area Piston-Pumping System. Leonard Greiner (ARS member), assignor to Experiment Inc., Richmond, Va.



Exterior view, above, and section through rocket featuring differential-area piston-pumping system.

Needed—New Inventions

The National Inventors Council of the U.S. Dept. of Commerce has released a new list of problems for inventors, many of them involving space technology. The list may be obtained on request from NIC, Dept. of Commerce, Washington 25, D.C. C. S. Daper of MIT currently chairs NIC.

ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner

Flight Propulsion Laboratory Dept.

General Electric Co., Cincinnati 15, Ohio

RP-1 (Hydrocarbon Fuel)

RP-1 and other fuels of its type (JP 1-6, JP 107A, kerosene, gasoline) have been the workhorse fuels for rockets for many years. They are cheap and readily available as well as being storable. They are also very suitable as coolants.

The properties of RP-1 vary, since it is not a pure compound, but a selected petroleum fraction meeting the specifications given in Military Specification MIL-F-25576A (USAF). Some of these specifications are shown in the first table. Representative properties are given in the second table. A fair estimate of the average over-all chemical composition for use in calculations is $C_{11.74}$ $H_{21.88}$, giving a molecular weight of 163.

Hazards

RP-1 is very similar to kerosene and may be treated as such from the point of view of safety. It is primarily a fire hazard and care should be exercised to avoid sparks or flames and to prevent vapor accumulation.

These hydrocarbons are harmless in contact with the skin if removed immediately, even in large amounts. Longer contact, however, will produce skin irritation evidenced by redness and later by blister formation; therefore, gloves are recommended. Eye contamination results in immediate irritation and should be avoided by the use of safety goggles. Inhalation or ingestion can be dangerous in amounts as large as 1000 ppm. Personnel who are particularly sensitive to these hydrocarbons may require protective clothing.

Materials for Handling

Any metals except lead, cadmium, and zinc may be used. Cadmium is attacked by the mercaptans in the fuel, and this effect is accelerated in the presence of water. Naphthenic acids readily attack zinc to yield zinc naphthenates which are soluble in the fuel. These acids are not limited by the fuel specifications. Concentrations of naphthenic acids up to 2 percent in the fuel had no affect on aluminum alloys, brass, copper, cadmium, steel, nickel, or tin. Lead, however, was attacked. In water extracts of the fuel, 52S aluminum alloy suffered consistent pitting corrosion when it was coupled to brass, copper, or lead, or in the presence of lead or copper ions. Apparently, cadmiumplated steel, copper, brass, zinc, and lead are more susceptible to fuel corrosion than tin, steel, black iron, magnesium, and aluminum.

Most gasket materials are suitable for use with hydrocarbon fuels with the exception of rubbers. Most rubbers are attacked by the mercaptans in the fuel. Buna N rubbers, however, proved stable even to mercaptan concentrations of 0.05 percent.

Cost and Availability

RP-1 is extremely cheap, with the price ranging around 10 cents per gallon or about 1.5 cents per pound. It is available in any quantity from a number of oil companies. The U.S. jet-fuel consumption is about 2 billion pounds per year. The hydrocarbon fuels have the additional advantage of being readily available at any Air Force Base.

Table 1 Requirements of MIL-F-25576A (USAF)

Distillation:	
Initial boiling point	*
10% point	365 F min
10% point	410 F max
50% point	*
90% point	*
End point	525 F max
Loss, vol %	1.5 max
Gravity, degrees API	42.0–45.0
Existent gum, mg/100 ml	7 max
Potential gum, mg/100 ml	14 max
Sulfur, total, weight %	0.05 max
Mercaptan sulfur, weight %	0.005 max**
Freezing point	−40 F max
Heat of combustion (lower)	18,500 Btu/lb min
Viscosity at −30 F	16.5 centistokes max
Aromatics, volume %	5.0 max
Olefins, volume %	1.0 max
Flash point	110 F min

* To be reported—not limited.

** May be waived if the fuel is considered "sweet."

Table 2 Representative Properties of RP-1

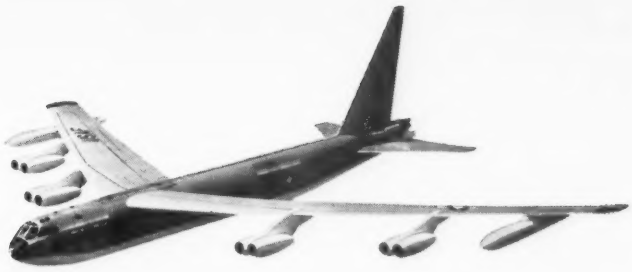
Boiling point	200 C
Freezing point	< −40 C
Liquid density at 25 C	0.80 g/cm³
Viscosity at 0 C	1.0 centipoise
Thermal conductivity at 25 C	0.07 Btu/hr ft F
Specific heat at 25 C	0.47 cal/gm C
Heat of combustion	18,660 Btu/lb

Table 3 Theoretical Performance of RP-1*

	Specific Impulse (sec)		Chamber Temperature**
Oxidizer	Frozen Flow	Equilibrium Flow	(Deg K)
O_2	286	300	3672
ClF_3	251	258	3528
95% H_2O_2	266	273	2914
RFNA	258	268	3231
N_2O_4	263	276	3447

* P_c = 1000 psia; P_e = 1 atm; optimum O/F ratio.

** Corresponds to equilibrium flow impulse.



KEARFOTT developed

and now produces

precise heading and vertical

reference systems

for the B-52 aircraft.

Engineers: *Kearfott offers challenging opportunities in advanced component and system development.*

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Contract awards

Mercury Pact for $33.6 Million Awarded to McDonnell Aircraft

McDonnell Aircraft, benefitting from a NASA boost in its initial order of 12 Project Mercury capsules to 20, has received a $33,600,000 contract from the space agency, which includes some capsule design changes.

Pershing R&D Continuation

The Army has awarded an $82,599,690 contract to The Martin Co. for continued research and development of the Pershing weapon system, bringing the total amount thus far allocated for the program for fiscal 1960 to $118,057,000. The Army also issued a $3,300,000 contract to Martin for publications and training for Missile Master maintenance personnel, while the Navy awarded the company a $2,000,000 contract for follow-up production of Bullpup transmitters.

Additional Terriers

Convair-Pomona has received a $25,200,000 contract from the Bureau of Naval Weapons for additional production of advanced Terrier Missiles.

Booster-Powered Takeoff

The Army Electronic Proving Ground has issued a contract to Gabriel Co.'s Rocket Power/Talco Div. for development and delivery of booster rockets which will enable pilotless drones to make direct takeoffs from a standstill position.

NSF Research Grants

MIT has received $599,200 in grants from NSF for extensive fundamental research in the materials sciences to be conducted by its new Laboratory of Chemical and Solid State Physics, specially created for the study.

Pentaborane Production

Callery Chemical Co. has been awarded a $9,000,000 AF contract for production of pentaborane.

Project Mercury Antennas

Canoga, a subsidiary of Underwood Corp., has been awarded a contract in excess of $1,000,000 for design and manufacture of all groundbased telemetry, communications, and command control antennas for Project Mercury.

SAGE Pact to Burroughs

A new AF contract for $7,980,000 in the SAGE program has been received by Burroughs Corp.

Hawks for the Marines

Raytheon has been awarded a $7,131,854 contract by the Boston Ordnance District to produce Hawk missiles for the Marine Corp.

Titan Control Valves

CompuDyne Corp. has let a more than $1,000,000 contract to Kieley & Mueller, Inc., Middletown, N.Y., for production of all of the automatic flow-control valves for operational propellant-loading systems at four Titan-missile bases.

ALRI Award for $9.5 Million

Electronic Communications, Inc., has received a $9,500,000 initial contract from Burroughs Corp., systems manager for the AF's ALRI (Airborne Long Range Input) system, for development and production of approximately one-third of the program.

Nike-Hercules Contract

The Army has awarded a $20,259,484 contract for work on the Nike-Hercules missile system to Western Electric Co.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, NASA, and Navy Contracting Office:

AIR FORCE

AFCRC, Laurence G. Hanscom Field, Bedford, Mass.

Modification of design of the Robin meteorological rocket balloon and fabrication of balloons, $51,321, **G. T. Schjeldahl Co.**, 202–206 S. Division, Northfield, Minn.

Investigation of solar-induced phenomena at magnetically conjugate points on the earth, $51,600, **Geophysical Institute, Univ. of Alaska,** College, Alaska.

Wind computers to be integrated into a complete airborne system, $52,678, **General Precision Lab., Inc.**, 63 Bedford Rd., Pleasantville, N.Y.

Automatic recording, high resolution, double beam, infrared spectrophotometer, $27,420, **Beckman Instruments,** 2500 Fullerton Rd., Fullerton, Calif.

Research and development of antennas for rocket trajectory and data transmission equipment and associated ground stations, $39,947, **New Mexico College of Agriculture and Mechanic Arts,** State College, N.M.

Design and development of instrumentation for the study of the density, pressure, temperature, and composition of the upper atmosphere, $71,192, **Control Equipment Corp.**, 19 Kearney Rd., Needham Heights, Mass.

R&D of instrumentation for research

NASA CONTRACTS FOR DECEMBER

Contractor	Obligation	Program
Ampex Corp.	$ 47,500	Magnetic tape recording system for Lewis' research facilities.
ARDC	$19,000,000	Initial NASA funding on $43,000,000 contract with Convair-Astronautics for airframe, stage integration, and upper-stage tanks of Centur. ARDC is supplying technical support,
Bowshot, Cooper, and O'Donnell Engineers	$ 70,000	Engineering design and drafting services for rocket systems research facility at Lewis.
Univ. of Denver Colorado Seminary	$ 119,000	Investigate ionization phenomena in hydrogen, nitrogen, and oxygen, using high velocity molecular beams.
Electronic Associates	$ 252,000	Analog computer system for data reduction work in X-15 program.
Jarrell-Ash Co.	$ 33,500	Spectrograph to find impurities in metals in basic materials research at Lewis.
McDonnell Aircraft	$33,600,000	Funding to cover contract changes in Mercury capsule design and layout, additional capsules, and support equipment.
ONR	$ 110,000	Funding for joint project involving ONR, NSF, and NASA for balloon-borne observatory. Princeton Univ. is providing management support.
Rensselaer Poly	$ 46,000	Investigate plasma properties of a variety of gases over wide range of pressure, electron, energies, and degrees of ionization by microwave techniques.
Tenney Engineering	$ 80,000	One simulated altitude test facility at Atlantic Missile Range to test barometric switches, environmental and life support systems of Mercury capsule prior to launch.

rockets, $119,781, **Oklahoma State Univ. of Agriculture and Applied Science,** Research Foundation, Stillwater, Okla.

R&D leading to fabrication, assembly, and testing of biaxial pointing controls and associated telemetry problems, $59,775, **Univ. of Colorado,** Boulder, Colo.

R&D of circuitry for measurement of upper atmospheric density from rockets, $75,000, **Univ. of Utah,** Salt Lake City, Utah.

Research directed toward refinements of geodetic measurements techniques, utilizing terrestrial and spatial configurations, $45,000, **Georgetown Univ.,** Washington, D.C.

High frequency unidirectional antennas, $26,160, **All Products Co.,** Box 110, Mineral Wells, Texas.

AFMDC, ARDC, Holloman AFB, N.M.

Rocket motors for high-speed test track, $45,922, **Grand Central Rocket Co.,** P.O. Box 111, Redlands, Calif.

Guidance test sled, $38,315, **Coleman Engineering Co.,** 3500 Torrance Blvd., Torrance Calif.

Recorder in support of Project WS-133A, $31,470, **Ampex Data Products Co.,** 8467 Beverly Blvd., Los Angeles 48, Calif.

AFOSR, Director of Procurement, Washington 25, D.C.

Study of ultrasonic attenuation in metals at temperatures near absolute zero, $69,525, **Wayne State Univ.,** Detroit 2, Mich.

Nuclear structure models, etc., $71,864, **Univ. of California,** Berkeley, Calif.

High-intensity plasma jets, $85,498, **Plasmadyne Corp.,** Santa Ana, Calif.

Electromagnetic chemical reaction, $151,052, **Republic Aviation,** Farmingdale, N.Y.

Electromagnetic plasma acceleration, $169,972, **Litton Industries,** Beverly Hills, Calif.

Solids in magnetic fields, $36,765, **Ohio State Univ.,** Columbus, Ohio.

Semiconducting and insulating materials, $77,500, **Battelle Memorial Institute,** Columbus, Ohio.

Ultrasonic waves in metals, $75,554, **Brown Univ.,** Providence, R.I.

Ferromagnetic systems, $58,300, **Franklin Institute,** Philadelphia, Pa.

Crystalline imperfections, $26,110, **Cornell Univ.,** Ithaca, N.Y.

Organic semiconductors, $34,439, **Armour Research Foundation,** Chicago, Ill.

Deformation of metals, $55,545, **Franklin Institute,** Philadelphia, Pa.

Continuation of research in a study of heating and acceleration of plasma by magnetic fields, $82,924, **Plasmadyne Corp.,** 3829 S. Main St., Santa Ana, Calif.

Research on plasma dynamics, $75,000, **CalTech,** Pasadena, Calif.

Ogden Air Materiel Area, USAF, Hill AFB, Utah.

Rework, overhaul, and acceptance testing of RJ 43-MA-9 ramjet engines, $595,000, **Marquardt Corp.,** 16555 Saticoy St., Van Nuys, Calif.

Data in support of the IM99A Missile, $30,071, **Boeing,** Pilotless Aircraft Div., P.O. Box 3925, Seattle 24, Wash.

Magnetic tape for compilation of statistical data, $53,575, **Ampex Corp.,** 934 Charter St., Redwood City, Calif.

WADD, ARDC, USAF, Wright-Patterson AFB, Ohio.

Qualification testing of electromechanical devices, $375,000, **United Testing Laboratories,** Div. of United Electrodynamics, 573 Monterey Pass Rd., Monterey Park, Calif. Negotiated procurement.

ARMY

Army Ordnance District, Birmingham, 2120 Seventh Ave., N. Birmingham 2, Ala.

Improved Honest John missiles, $463,694, **Douglas Aircraft,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Engineering and design services and specialized services for manufacture of special tooling and missile components, supplement, $767,633, **Hayes Aircraft Corp.,** P.O. Box 2287, Birmingham, Ala.

Army Ordnance District, Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Research and development of Sergeant missile system, $1,831,357, **Sperry Rand Corp.,** 322 N. 21 West, Salt Lake City, Utah.

Design and development of NAA H-1 motors, $87,260, **North American Aviation,** 6633 Canoga Ave., Canoga Park, Calif.

Fuze, warhead, $28,082, **Waste King Corp.,** 3301 Fruitland Ave., Los Angeles, Calif.

Rocket engines, $45,000, **North American Aviation,** 6633 Canoga Ave., Canoga Park, Calif.

Wind tunnel test equipment for Nike-Zeus, $72,085, **Task Corp.,** 1009 East Vermont St., Anaheim, Calif.

Hawk RP-77D target missile flight services, $57,319, **Radioplane,** Div. of Northrop Corp., 800 Woodley Ave., Van Nuys, Calif.

Guided missile research and development, $2,198,253, **CalTech,** 1201 E. California St., Pasadena, Calif.

Wind tunnel testing for Nike-Zeus, $1,139,475, **CalTech,** 1201 E. California St., Pasadena, Calif.

Army Signal Supply Agency, 225 S. 18th St., Philadelphia 3, Pa.

Courier communications satellite modification, $200,000, **Philco Corp.,** Philadelphia, Pa.

Models of passive targets high-altitude wind sensing equipment and related items, $236,418, **Cooper Development Corp.,** Monrovvia, Calif.

IPM for micromodule production system, modification, $7,999,416, **RCA,** Defense Electronics Products, Camden, N. J.

NASA

Ames Research Center, Moffett Field, Calif.

High-speed motion picture camera for high-speed impact studies in the hypervelocity ballistic range, Moffett Field, Calif., $91,745, **Beckman & Whitley, Inc.,** 973 San Carlos Ave., San Carlos, Calif.

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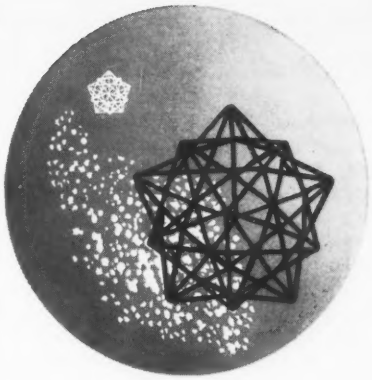

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SCIENTISTS

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Expanding the scope and depth of present programs is Republic's recently completed $14 million Research and Development Center. Extensive facilities here are an invitation to professional men to realize the future by solving today's most perplexing problems.

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Mr. George R. Hickman
Technical Employment Manager,
Department 3D

REPUBLIC AVIATION

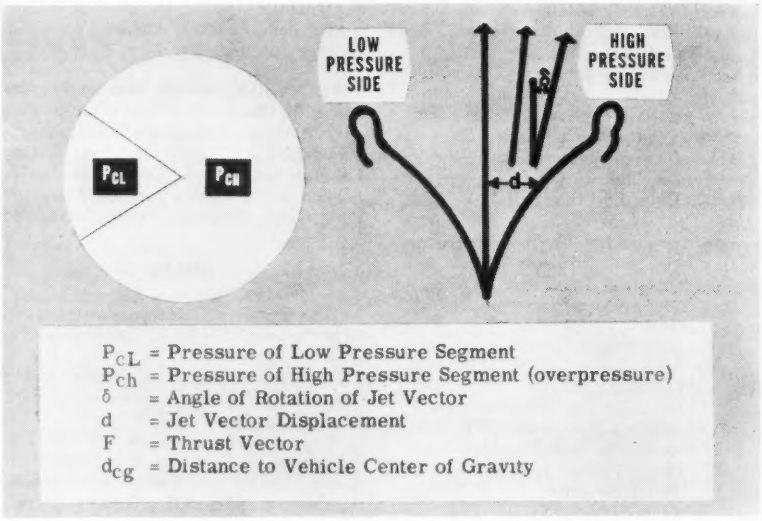
Farmingdale
Long Island, New York

Plug Nozzle

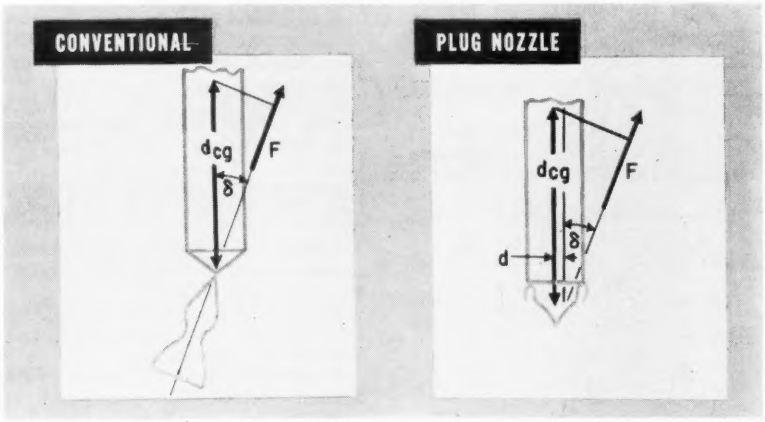
(CONTINUED FROM PAGE 24)

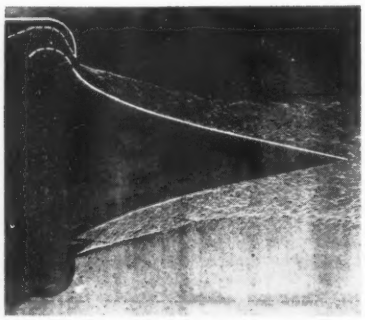
units which can be easily developed, similar to a cylinder in a piston engine, become the scalable part of the complete combustor. The basic strip injector concept involves replacing the usual circular combustor with an annular segmented combustor, as shown in the top figures on page 23.

Experimental investigation has indicated that steady-state oscillatory modes can be suppressed if dimensions can be kept small enough. For this reason, combustor width is kept down to suppress radial oscillatory modes. The circumferential combustor length "L" then becomes the variable for controlling the tangential or circumferential mode. Just as it is possible to determine experimentally a longitudinal-mode stability diagram for small-diameter chambers and, accordingly, adjust the chamber length for stable operation, it must be possible to determine a similar diagram as a function of the combustor circumferential length, as shown in the bottom drawings on page 23. From this, the appropriate combustor segment length can be selected. Identical combustor segments can then be assembled into a complete annular combustor to form an integral chamber.

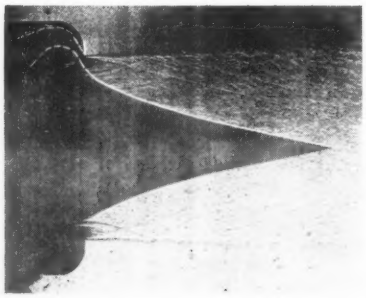

LOW PRESSURE SIDE
HIGH PRESSURE SIDE
P_{CL}
P_{CH}
δ
d
P_{cL} = Pressure of Low Pressure Segment
P_{ch} = Pressure of High Pressure Segment (overpressure)
δ = Angle of Rotation of Jet Vector
d = Jet Vector Displacement
F = Thrust Vector
d_{cg} = Distance to Vehicle Center of Gravity

Schematic explanation of aerodynamic thrust vector controls (above) and comparison with conventional system (below).





Shadowgraphs of plug nozzle flow fields at two different pressure ratios with no external flow. Above, $\lambda = 20 = P_c/P_a$; below, $\lambda = 75 = P_c/P_a$



There are many ways in which such combustors can be combined with a nozzle and other necessary system components to form attractive propulsion system configurations. One possible configuration is a segmented annular combustor combined with a "plug nozzle." The drawing on page 22 depicts an example of a plug-type turbopumped liquid-propellant engine. The combustors are located around the base of the nozzle and, in this particular unit, the turbine exhaust is brought out through the center of the nozzle.

Plug nozzles have been under investigation for some time, primarily by manufacturers of airbreathing engines and NASA's Lewis Research Center. As opposed to the conventional De Laval nozzle, a substantial portion of the supersonic flow expansion occurs externally, being confined only by the plug surface, which represents one bounding streamline and the atmosphere. The outer jet surface is a free boundary which adjusts itself according to the existing ambient conditions. Such flow is in accordance with the well-known Prandtl-Meyer expansion theory.

Some typical shadowgraphs of the flow field for a given plug nozzle at two pressure ratios are shown on this page. It is significant that the jet cross-sectional area at the plug tip, which is the effective nozzle exit area, adjusts itself in accordance with the existing pressure ratio. Below the design pressure ratio, the variation is approximately such that the exit-to-throat ratio corresponds to the ideal value required by the existing pressure conditions. As a result, the aerodynamic performance of a plug nozzle operating below the design point is higher than that of a conventional nozzle. Above the design point, the theoretical performances are identical, as shown in the graph on page 24.

As pointed out earlier, the plug-nozzle concept was the direct result

of a search for an engine-design configuration to provide more rapid and less expensive development. Further analytical and experimental investigations have since indicated that it possesses several other advantages. Such engines are naturally short and compact and produce a well-packaged propulsion system. In fact, studies indicate that the plug-type engines would be about half the length of conventional configurations. This makes them attractive not only for first-stage booster applications but also for medium-thrust upper-stage propulsion systems. Similarly, the weight of the plug-type engine compares favorably with that of the conventional unit for the same thrust level.

A really significant bonus in the investigations has been the experimental verification that this particular rocket-engine configuration provides an easy means for eliminating the gimballing structure normally required, thereby permitting a rigid connection between the propulsion system and the vehicle. This eliminates the need for stress redistribution as is required in the usual vehicle design, and as carried out by the thrust structure and gimbal system. This reduces vehicle length and improves missile aerodynamics by making for a cleaner aft end.

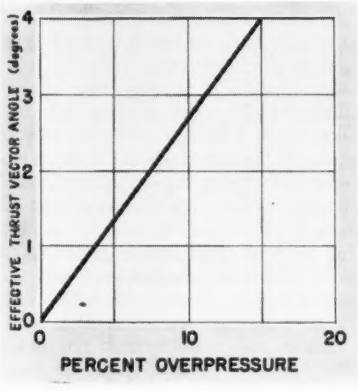
Thrust-Vector Control

The multicell combustor provides the means to deflect the gas jet with respect to the nozzle axis to produce "aerodynamic" thrust-vector control. If the chamber pressure is raised in one of the cell combustors and lowered in the others in such a manner that the total propellant flow rate is kept constant, then the gas jet undergoes a rotation and translation with respect to the axis of symmetry of the plug. These effects, shown in the illustrations on page 100, are additive as far as thrust vector is concerned. A typical set of data showing the variation of effective thrust-vector angle versus overpressure in the higher pressure combustor cell is shown in the graph on this page.

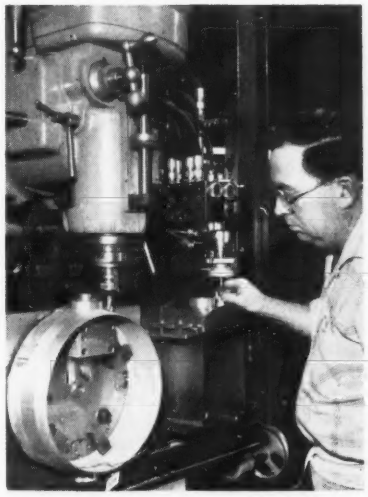
In conclusion, the plug nozzle offers an exciting advance in rocket-engine technology. First, it provides the operation advantages of reduced size, elimination of gimballing, and improved low-altitude performance. Of even greater importance, as envisioned by GE, the concept avoids both the complexities associated with clustering complete engine systems and the problem of combustion instability inherent in a large single-chamber design.

As such, it provides a means of achieving any desired thrust level with significantly reduced development time and cost. ♦♦

Effect of Percent Overpressure on Effective Thrust Vector Angle



Contour Machining of Forged Molybdenum



Pure molybdenum jetavator being contoured on Gorton 3D Mill.

Considered impractical not long ago, contour machining of forged molybdenum is now being done on a production basis at Custom Tool & Mfg. Co., Minneapolis, Minn.

In the photo, the support bosses of a jetavator are being contoured on a Gorton 3D Mill equipped with a True-Trace attachment. This job is completed in two passes, using a high-speed, two-flute, steel end mill cutter. Tolerances are held within 0.001 in., with a surface finish of 63 micro (RMS) or better.

United Research Corporation of Menlo Park, a subsidiary of United Aircraft Corporation, announces it has changed its name to

UNITED TECHNOLOGY CORPORATION

Objectives of this company have evolved to encompass not only research but also development work in the fields of solid and liquid propellants through complete qualification of rockets and of advanced propulsion systems.

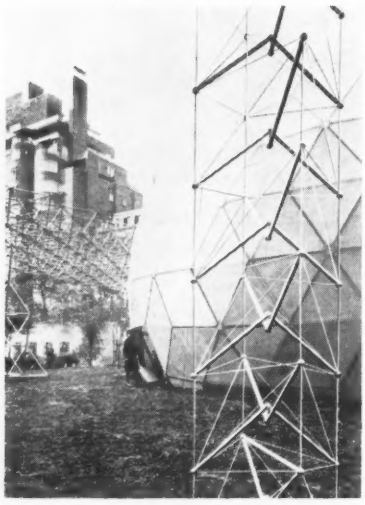
The new name — with its emphasis on "technology" — clearly defines the scope of the activities being undertaken.

Construction of two multi-million dollar permanent facilities to implement the objectives of the corporation is now underway. A Research and Engineering Center is being built on a 25-acre site in Sunnyvale; a Development and Test Center in the foothills some 10 miles southeast of San Jose, California, in the prime living area of the San Francisco Peninsula.

UNITED TECHNOLOGY CORPORATION

P. O. Box 365 • Menlo Park, Calif.

Tensegrity for Space Structures



Buckminster Fuller's tensile-stress forms, shown here on display at New York's Museum of Modern Art, exhibit the lightness and strength that will be a premium in space. The focal points of the tower in the foreground are mating nuts and bolts of aerospace design (220,000-psi tensile strength) made by Standard Pressed Steel Co.

Multistart Rocket Engines

(CONTINUED FROM PAGE 37)

injects flame into the main chamber, as shown in middle drawing, page 35.

The author some years ago proposed the use of mechanically generated sparks which traverse the mixture in the thrust chamber and carry ignition energy to a larger volume than can be electrically sparked, as shown at bottom of page 35. This method also has the advantage of being fairly altitude-insensitive, but it is unable to cope with large quantities of liquid and vapor that may enter a thrust chamber on start. The system involves the use of cerium-alloy "flints," generating many small sparks which travel for several inches through the combustible vapor mixture, each spark acting as a small locus for ignition.

Better than spark techniques for starting is the use of auxiliary hypergolic slugs of propellant when nonhypergols are used. For instance, in the GE-NASA Vega engine, based on the Vanguard first stage, the mixture of lox-kerosene was ignited by a separately injected slug of material which began the combustion. This system worked so well that repeated starts were possible during any one firing program on the propulsion system.

Such schemes are relatively simple, or at least can be made reliable, since no new techniques are needed. By selection of a third hypergolic liquid which has physical properties compatible with the rest of the propulsion system and by a proper choice of plumbing and tankage, this approach looks rather promising for future applications. A variation of such a scheme involves injection of the hypergolic slug ahead of one of the propellants which does not react with the slug. This method requires less plumbing and flow controls than the "third liquid" system but necessitates very precise timing and correlation of flow controls and pressure switches. Both these systems are shown on page 37.

In general, the requirement for restart capability means a new approach to propulsion-system design. The placement of flow controls, such as propellant valves, for example, requires careful attention since long shutdown transients and surges complicate the starting picture. It is true that occasionally a simple approach, such as that used in the GE system, can be adapted to an existing engine. Nevertheless, the capabilities of the pressurization pumping system must be extended.

It is possible to minimize propellant "dribble" and hard initial or terminal transients by locating flow controls near the element to be controlled. For example, by installing a propellant valve or manifold coverplate within a propellant injector, i.e., behind the injector face, it is possible to effect a very rapid positive opening and closing program for one propellant. This approach is, however, mechanically impractical for chambers above, say, 10,000 lb of thrust, because a large mass of valve metal and a heavy driver mechanism would be required as injector diameters and manifolds become inordinately large.

Liquids Dominant

The liquid-propellant propulsion system seems to preempt this field, as it does such others as throttling. Is there a place for the solid propellant system in the area of re-start? The answer at this time must be "not likely," at least not in the near future. The very nature of the solid rocket, with its elemental simplicity, almost contradicts the notion of controllability. It is a refutable argument to state that "the simplicity and reliability of the solid can be mated with the flexibility of the liquid."

Furthermore, in those areas of restart applications mentioned earlier, a high specific impulse liquid system is most efficiacious. This does not mean that ancillary techniques—which result is something like re-start capability—have not been and may not be tried. In some of the U.S. deep-space probes, for example, clusters of small solids were fired in pairs at a time, in order to yield a required valve of velocity increment. Similarly, solids fired successively and individually could be used for such retro-purposes as a lunar soft landing. For these purposes, a rather startling order of total impulse accuracy is required, predictable from a very thorough quality control and rocket qualification program.

Small Solids Useful

Thus, in this rather oblique approach to velocity trim control, it seems more logical to anticipate a continuing use of smaller solids or auxiliary solid gas generator systems. Solid proponents, commendably, are not letting the seemingly great technical impracticabilities dismay them. Such ideas as the injection of an igniter fluid or small solid explosive charges into the solid's combustion chamber have been openly discussed for re-ignition. The "hybrid rocket" is an example of the liquid-solid approach wherein a liquid propellant, such as hydrogen peroxide, flowing through a decomposer and injector, continuously reacts with a solid fuel in a rocket combustor. The combustion (and therefore thrust) can be stopped merely by stopping the liquid's flow, while re-ignition occurs on flow resumption.

Firing small solid ignition charges into the rocket chamber means almost the complexity (and nearly the weight) of a gun with a breech and isolation valve and all its various appurtenances. A variation on this proposal is the appending of small solid rockets to the main chamber, so that a hydra-head results. When thrust ceases (presumably by some means such as vent valving) and re-ignition is desired, the auxiliary chamber fires into the main combustor, and across the residue of grain, to once again "light the fire."

It could appear that all such re-start proposals mean added complexity and weight, tending to drive the "simple" solid inexorably toward the liquid system—which, with its admitted complexity, at least has the virtue of a higher attainable impulse and a generation of experience with flow-control design. While breakthroughs in solid technology would, of course, change this picture, controllable solid usage seems destined to embrace thrust cutoff and simple velocity and vector trim. There is much work to be done here, but this will not prevent the indefatigable solid enthusiasts from con-

tinuing experimentation with re-ignition techniques. One can only wish them luck.

In summary, then, certain manned aircraft, orbital, lunar, and deep-space missions require rocket-propulsion systems capable of command re-ignition or re-start. Modifications to existing systems, or better, tailoring of the engine-vehicle complex to this purpose, can fill the requirements. Hypergolic propellants simplify ignition problems but do not remove the requirements for proper sequencing of flow-control operation, adequate pressurization and/or gas-turbine pumping systems, and reliable design of the propulsion sequence control "black boxes."

There is nothing magical about restart design requirements that precedence and existing technical capability have not established.

References

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"Space Technology," Seifert, Howard (Editor), John Wiley & Sons, pp. 16–27.

Stehling, Kurt R. and Diamond, P., "Rocket Engine Flow Controls," *Journal of the American Rocket Society*, vol. 23, May–June 1953.

Stehling, Kurt R., "Aspects of Vanguard Propulsion," *Astronautics*, January 1958.

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ARS News

(CONTINUED FROM PAGE 70)

meeting, the Chapter held elections for the term from February to July 1960. The following were elected: Mohammed Ahmed, president; William Twa, vice-president; Jose E. Velez, secretary; Martin Pearce, treasurer; and Stephen J. Colaprete, librarian.

Immediately following the elections, three movies were shown– "Into the Yonder," "Road to the Stars," and "Search into Space."

—Jose E. Velez

Univ. of Michigan: The Chapter held its first meeting of the new semester in February, with **Leslie Jones** of our High-Altitude Research Laboratory speaking on "Rockets for University Research."

—Judith M. Forde

Univ. of Washington: At the January Meeting, **Michael E. Maes** of Boeing's advanced systems research group on flight technology gave a very interesting talk on "The State of the Art of Advanced Propulsion Systems."

—Patricia L. Blake

TECHNICAL COMMITTEES

Bioastronautics: The bioastronautics Committee, in conjunction with the ARDC, Office of the Staff Surgeon, AF Missile Test Center, will hold a special classified (Secret) bioastronautics briefing for key representatives of industry at Cape Canaveral, May 12–13. Attendance is limited to 35 participants, and attendance is by invitation only. The tentative program calls for a tour of the Cape and classified briefings on the Mercury and Discoverer programs and missile launch facilities.

CORPORATE MEMBERS

The R&D Dept. of **ACF's** Erco Div. and the Alexandria branch of its Avion Div. have been moved into a new 37,800-sq ft facility at 52nd Ave. and Jackson St., Bladensburg, Md. . . . **Aerojet** has combined its Structural Plastics Div. and Materials Dept.-Azusa Operations into the new Structural Materials Div. . . . **Alcoa** has purchased Rea Magnet Wire Co. in exchange for some of its common stock. A mate to the 14,000-ton extrusion press for outsized aluminum shapes has been installed at Alcoa's Lafayette, Ind., works . . . **Atlantic Research Corp.** has formed a Space Vehicles Group with headquarters at 188 N. Berkely St., Pasadena, Calif. In another step, ARC acquired Desomatic Products, Inc., Falls Church, Va., with operations in the gas processing field.

Bell Aircraft announces development of a plasma-jet generator capable of producing temperatures up to 18,000 F to test materials for satellites and spaceships . . . **Bendix Aviation's** missile section has been set up as a separate division, the Bendix Mishawaka (Ind.) Div.

An expansion program running into $4 million is going on at **Douglas Aircraft.** By December, the firm expects to have its missiles and space systems engineering activities, formerly divided between its Santa Monica and Culver City facilities, consolidated into one engineering center at the latter facility. Some 3000 engineers, scientists, technicians, and clerical workers will be housed in the center.

In an expansion move, **General Dynamics** has leased six floors at 9 Rockefeller Center, N.Y.C., formerly the Time & Life Building, which will be renamed the General Dynamics Building later this year . . . **GE** has established a new defense systems engineering company, Apparaten-industrie Defense Electronics, N.V., in The Hague, Netherlands, to participate with NATO countries in integrating their engineering, manufacturing, and management capabilities.

ITT Laboratories announces addition of a second research facility at 4019 Transport St., Palo Alto, Calif. . . . **Minneapolis-Honeywell Regulator Co.** has begun full-scale production of precision ceramics components . . . **North American Aviation's** Rocketdyne Div. has announced formation of its new major product organization, Liquid Propulsion Operations, with headquarters at Canoga Park . . . **Northrop's** Page Communication Engineers, Inc., subsidiary has set up a Telecommunications Directorate.

Philco Corp. has formed an independent Research Div. as preparation for its move to a new research center in early 1961 . . . Twenty-five acres of land in Farmingdale, N.Y., donated by **Republic Aviation** will be the site of Brooklyn Poly's new Polytechnic Center for Graduate Study and Research . . . Aerolab Development Co., Pasadena, specialist in aerophysics research, has been acquired by **Ryan Aeronautical Co.** At its electronics research center, Ryan recently added environmental test and microwave laboratories and a boresite tower range for its Doppler navigation research program.

Standard Letter Symbols For Rocketry Available

ASME has just published the new American Standard Letter Symbols for Rocket Propulsion, ASA Y10.14-1959, approved last September by the American Standards Assn. Sponsored by ASME, in collaboration with ARS and IAS, the standard letter symbols are available from ASME, 29 West 39th St., New York 18, N. Y., at a price of $2 per copy, with quantity discounts offered.

ARS Human Factors Conference Planned in Dayton Oct. 10–12

An ARS Human Factors and Bioastronautics Conference will be held at the Biltmore Hotel in Dayton, Ohio, Oct. 10–12. The tentative program for the conference includes sessions devoted to anthropometrics, bionics, bioinstrumentation, human factors aspects and industrial relations, and government contract research in the life sciences. Tours of the Wright Air Development Div., the Air Museum, and the Occupational Medicine Hospital are also planned, and two banquets and a luncheon are tentatively scheduled. ♦♦

ASTRONAUTICS Data Sheet — *Materials*

MAGNESIUM CASTING ALLOYS

Compiled by C. P. King

Materials and Process Section
Marquardt Co., Van Nuys, Calif.

Cast alloys of the lightest structural metal—magnesium—have found many applications in aircraft and missiles. Sand, permanent mold, and die casting are the principal foundry methods employed, although investment, plaster, shell, and centrifugal castings are also being made.

Alloys for Room Temperature Use

AZ91C and ZK51A are used for their high strength up to 300 F. AZ91C has good castability and weldability, needing solution treatment and aging for development of its maximum mechanical properties. ZK51A needs only aging but is prone to foundry difficulties and is not weldable.

Alloys for Elevated Temperature Use

HK31A has good short-time strength up to 800 F and good creep characteristics. It requires solution treatment and aging as does QE22A, but the latter has superior foundry properties and good weldability. EZ33A alloy has good creep strength, excellent castability and weldability. It requires only an aging treatment.

Other Alloys

Used to a lesser degree for more specialized applications are the following alloys with their principal characteristics.

Service up to 300 F:

AZ92A-T6—High yield strength; good ductility and pressure tightness.

AZ63A-T6—High ductility and toughness.

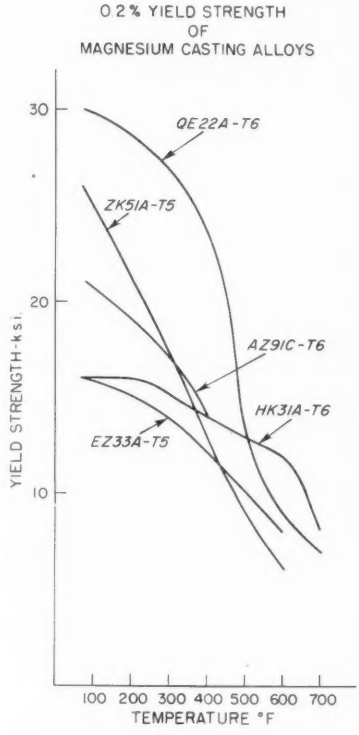
Service from 300 to 500 F:

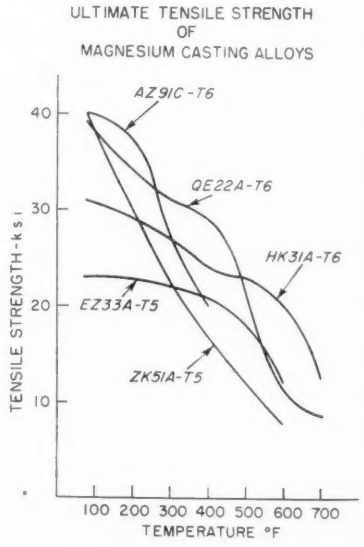
EK30A-T6, EK31A-T6, and EK41A-T6—Good pressure tightness; good castability and weldability.

ZH62A-T5—High yield strength; good castability and weldability; does not require solution treatment.

Service from 500 to 700 F:

HZ32A-T5—Excellent castability; excellent creep properties at high temperatures; good pressure tightness; does not require solution treatment.





Physical Properties of Magnesium Casting Alloys

Alloy	Density (lb per cu in.)	Thermal Conductivity at 68 F (CGS units)	Electrical Resistivity at 68 F Microhm cms	Coefficient of Thermal Expansion 68–212 F
AZ91C-T6	0.0652	0.11	16.2	0.0000145
HK31A-T6	0.0647	0.22	7.7	0.0000145
EZ33A-T5	0.0659	0.24	7.0	0.0000145
ZK51A-T5	0.0653	0.20	8.4	0.0000145
QE22A-T6	0.0658	0.24	6.8	0.0000145

Chemical Composition of Magnesium Casting Alloys

Alloy	Composition, percent Al	Zn	Zr	Th	Rare Earths	Ag
AZ91C	8.3–9.2	0.5–0.9	—	—	—	—
HK31A	—	—	0.5–1.0	2.5–4.0	—	—
EZ33A	—	2.0–3.5	0.5 max	—	2.5 –4.0	—
ZK51A	—	3.5–5.5	0.5–1.0	—	—	—
QE22A	—	—	0.4–1.0	—	1.75–2.25	2.0–3.0

Thermal Protection

(CONTINUED FROM PAGE 41)

long as the individual particles do not sinter or agglomerate under external pressures or when exposed to high temperatures, resistance to heat flow will be formed at the surface of each particle. In fibers or powders, the gas filling the interstices between particles is usually the dominant contributor to over-all heat flow for moderate temperature differences. In general, large gas molecules have low thermal conductivity. Therefore, some benefits could be derived from the use of a gas of high molecular weight. This technique, however, limits the improvement in insulating value to approximately the difference in free gas conductivity between the gas and the air. A far greater improvement can be obtained by removal of the gas filling the spaces between particles—that is, by "vacuum insulation."

Previous work

Vacuum insulation is certainly not a new development. In 1898, James Dewar demonstrated that an evacuated space between two suitably silvered glass vessels forms an effective heat barrier. For quite some time it was widely held that air had the lowest thermal conductivity of any combination of materials. In 1910, however, Smoluchowski showed that thermal insulators more effective than air could be produced from fine powders subjected to a moderate vacuum. The low values of thermal conductivity thus obtained can be explained by the following effects, as indicated in the graph on page 40.

1. As the pressure is lowered and gas molecules are removed, less heat is transferred after the mean free path of the molecules exceeds the average particle spacing.

2. Thermal conductivity at that point decreases substantially, until a lower limit is obtained when most of the gas molecules have been removed. The larger the particle spacing, the lower the pressure required for the thermal conductivity to approach its limiting value.

3. At this lower limit, the thermal conductivity still has a finite value because heat can be transferred by radiation, solid conduction between the particles, and residual gas conduction.

Although the amount of radiant heat passing through an insulation in cryogenic applications is far less than in high-temperature applications, heat so transferred plays a major role in the over-all performance of the system. Maintaining the insulating effectiveness obtained by the removal of environmental air and by the breaking up of conduction paths requires the attenuation of radiant energy that otherwise might pass through the material and nullify the benefits derived from reduced heat transfer by other mechanisms.

To assure the structural integrity of a thermal protection system, two approaches can be used. In the first, the insulation is placed in a space between two pressure vessels, with the inside vessel containing the material to be insulated, and the outside vessel designed so that it will withstand external pressures and other outside loads. Suitable supports should be provided to tie the inner vessel to the outside vessel, because the insulation need not be designed to carry loads. Despite the high insulating effectiveness thus produced, a considerable weight penalty makes this design almost impractical for space vehicles. However, it has been used widely in the transportation and storage of cryogenic fluids.

In the second approach, the insulation is designed to be load-bearing. Thus, supports and heavier pressure vessels can be eliminated. Moreover, the thermal protection system can be shaped more easily and made to conform to the contours of the surfaces to be insulated. Thin-skinned vacuum insulation—a term used to describe a thermal protection system's ability to carry and transmit loads imposed upon it after it has been evacuated—has been developed to confine the insulation and hold a desired vacuum without appreciable diffusion for extended periods. This type of insulation, however, must still rely on an underlying load-bearing structure or vessel to which loads can be transmitted. Because a load-bearing insulation has a higher density and, hence, increased weight, its thermal conductivity should be lower than that of a lighter insulation to be equally effective. An index of the product of thermal conductivity and density allows us to compare different insulating materials. The choice of design must be governed by the magnitude of the index applied to the complete system.

Storable Cryogenics

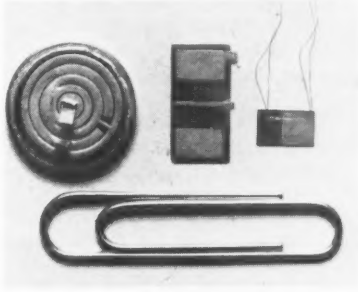
Thermal protection systems for cryogenic fluids such as liquid oxygen, liquid nitrogen, or liquid hydrogen are being developed so that such fluids can be stored aboard a space vehicle for an extended period. Thus, the complexity of propellant fuel-handling systems is reduced, and cryogenic fluids can be carried during space missions without incurring substantial losses caused by boiloff of the gases in the storage container.

To obtain the most efficient cryogenic insulation, we must mount the greatest possible number of radiation shields of low emissivity in series and separate them from each other and the boundaries by spacers. These shields must have the lowest possible thermal conductivity, have a minimum area of contact, and be under a high vacuum. Although a number of material combinations have been investigated for the attainment of these objectives, there is no theoretical limit to the very low thermal conductivities of such multiple-layer radiation-shield insulation, since it is theoretically possible to reduce both the thickness of the radiation shields and the thermal conductivity of the spacers and obtain still higher insulation efficiencies.

A protection system for cryogenic fluids using multiple-layer radiation-shield insulation may be composed of alternate layers of thin reflecting foils of aluminum and spacers of low conductivity materials with only a few thousandths' of an inch thickness as-

Getting Ready For Payoff in Space

"This is the way to go for payoff in space activities," was how an ARDC spokesman characterized molecular electronics, the developing science of giving a single piece of solid-state material the function of a many-componented device. Recently, the Westinghouse Electric research group headed by S. W. Herwald demonstrated the pictured products of their work to date on molecular electronics. These were three of some 20 demonstration devices. From the left, a two-stage video amplifier, a free-running multivibrator, and an audio amplifier.



Work on molecular electronics has rightly been termed fabulous. A hint of things to come was given by Harry Kihn of RCA in the May 1959 *Astronautics.*

sembled in sandwich form, as shown in the photo on page 41.

The open space between the vessel to be insulated and the outside shell is filled to the required thickness with this type of insulation and evacuated to a pressure of the order of 10^{-6} mm of mercury, depending upon the particle size and the density of the spacer materials. A 1-in.-thick assembly of 60 layers of aluminum foil with alternate submicron-diameter glass-fiber spacers evacuated to 10^{-6} of mercury and insulating a tank of liquid nitrogen can provide up to 500 times greater insulating effectiveness than the insulation commonly used in household refrigerators. Because of this very high insulating effectiveness, both the thickness and therefore the weight of such a thermal protection system can be minimized.

Attaining High Vacuum

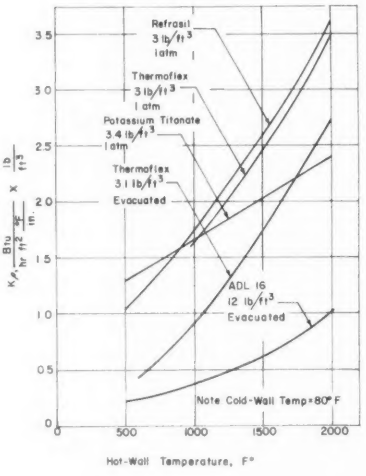
A flexible outside shell covering the multiple-layer radiation-shield insulation acts as a vacuum barrier which needs to be only thick enough to withstand diffusion, while the insulation is designed to withstand the compressive forces of atmospheric pressure or aerodynamic loads. The attainment of a high vacuum in the insulated space is not so difficult as it first appears because with cryogenic fluids, such as liquid hydrogen, any gas remaining in the space would tend to diffuse to the cold surface and either condense or freeze.

Once the vehicle has reached high altitudes, the thin shell no longer will have to be a good vacuum barrier, since the vacuum existing in space will be quite adequate to assure satisfactory performance of the insulation. Thus even occasional penetration by micrometeorites will not tend to deteriorate the insulating effectiveness and, provided that such penetrations are relatively small and few in number, the diffusion of air as the vehicle re-enters the atmosphere and experiences aerodynamic heating would not greatly reduce its effectiveness, particularly if the system is compartmentalized.

We can overcome the effects of aerodynamic heating on a structure either by letting the structural materials withstand the high temperatures generated on the exposed surfaces (hot structure) or by protecting the structure with insulation (cooled structure). The hot structure requires refractory materials that will not deteriorate in the high-temperature environment and that can be designed to carry the loads imposed on them without creating a weight penalty. Difficult problems confronting materials research and development of suitable refractory materials and necessary joining techniques have to be solved to make this approach feasible.

The cooled structure uses a thermal protection system and an underlying load-bearing aluminum structure designed in accordance with known criteria. This structure may be provided with an auxiliary cooling system.

The drawing on page 41 shows the arrangement of a thermal protection system applied to the outside surface



K_f OF VARIOUS INSULATING MATERIALS

of a space vehicle to protect the internal structure from the effects of aerodynamic heating. The design principles are the same as those employed in a protection system for low-temperature applications. The primary requirements are (1) materials that can withstand temperatures of 2000-4000 F; (2) the use of radiation cooling at the outside surface, which is coated so that it will reject a large portion of the heat generated by radiation to the surrounding space; and (3) attenuation of radiant energy passing through the insulation by suitable radiation absorbing and scattering media.

The development of thermal protection systems for hypersonic-speed vehicles required new high-temperature insulations. The illustration above shows the improvements that can be obtained in an insulating material if the radiant energy passing through it is attenuated. If this insulation is made to be load-bearing and is protected with an outside shell, aerodynamic loads can be transmitted to the underlying structure. A suitable design of the outside shell can compensate for thermal expansion caused by differentials in the temperature profile.

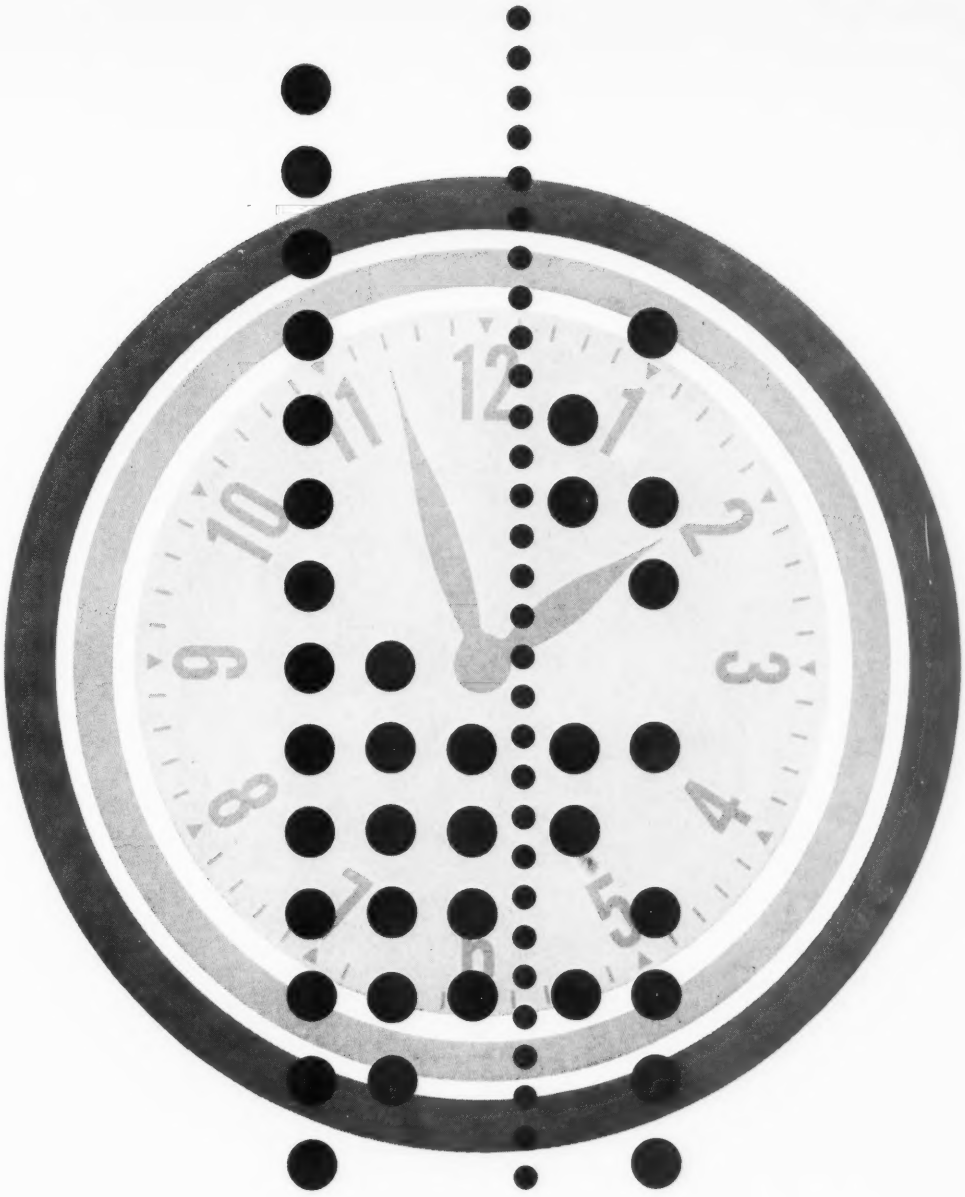
Space-Vehicle Requirements

Manned or instrumented space vehicles or stations may require a thermal protection system that can control the environment temperature of the capsule and either withstand solar radiation or conserve heat energy on a deep-space mission. For vehicle thermal control, systems of the type that we have discussed can be used. Since the system's effectiveness depends largely upon the gas pressure in the enclosed space occupied by the fibers or powders, a fairly simple control system can be devised. This system can vary the gas pressures in compartmented sections of the thermal protection system and thus increase or decrease insulating effectiveness. The variations in gas pressure can cause substantial changes in heat transfer through the thermal protection system, as shown in the graph on page 40. Thus, the side being heated by solar radiation may be so arranged that insulating effectiveness will be either increased or reduced, to provide a comfortable temperature in the environment of the space vehicle.

Such a thermal protection system, combined with surface coating on the capsule, could meet most of the conditions expected in space travel. Since very small pressure changes are needed, only a very small quantity of gas is required. The gas may be recycled for conservation over a long period of time. The instrumentation required to sense temperature changes and control vehicle environment can be simple and could be operated automatically by preset controls.

Systems we have discussed here indicate only new possibilities for the thermal protection of space vehicles. Other applications that have been considered include on-board storage of cryogenic fluids in missiles; temperature control of instrument packages; umbrellas to protect moon bases, personnel, and supplies from solar radiation; and casings for rocket engines using both nuclear and conventional fuels.

The successful development of thermal protection systems implies that some of the requirements for spaceflight can be met without undue sacrifice in vehicle performance and that such systems can increase our capabilities for space exploration through the use of materials and techniques now available to us. ♦♦



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are essential to missile development. Instruments must record every function against time... in fractions often finer than one ten-thousandth of a second. Reams of electronic and optical data must be collected, reduced and evaluated before any missile can become operational. Vitro designed, built and helped instrument the Air Force missile test center at Eglin Air Force Base, Florida. Today it operates the center's test ranges and tracking stations throughout the Southeast. At Eglin, Vitro and the Air Force, working as a team since 1952, are responsible for checkout of missiles, rockets, weapon systems, countermeasures, space probe vehicles and bombing techniques. Beyond this Florida site, other Vitro capabilities: underwater (torpedo) and electronic environmental ranges.

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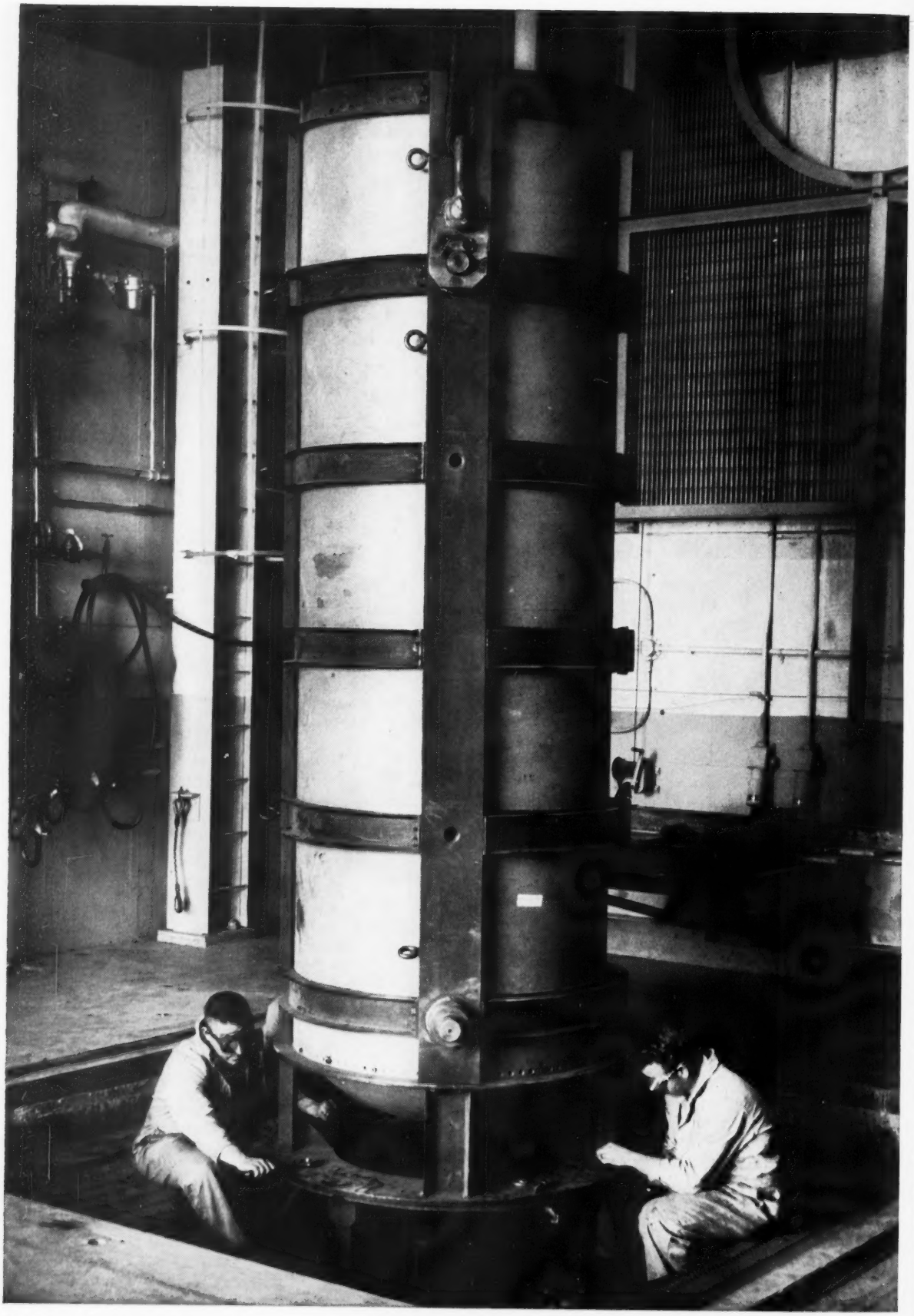

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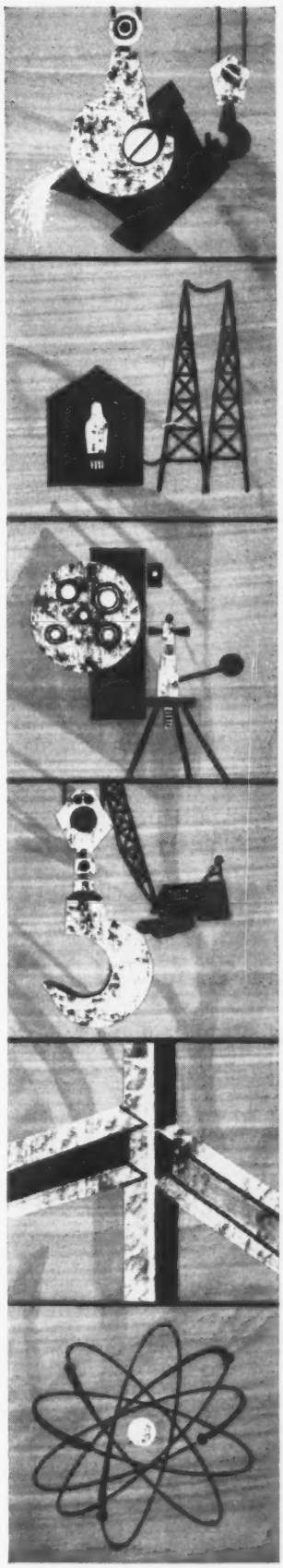

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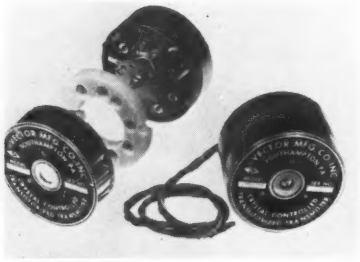
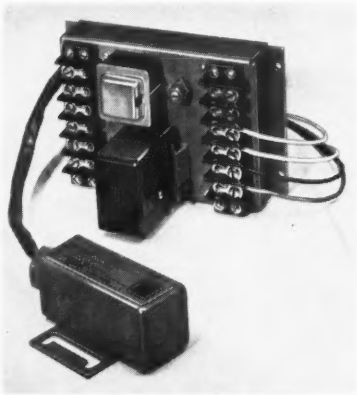


Telemetry Transmitter: Capable of transmitting the intelligence from any telemetry subcarrier system, type TRPT-250 transmitter is 2.6 in. in diam and 1.5 in. thick and weighs 9 oz; power output, 2.25 watt nominal; output impedance, 50 ohms; frequency range, 215 to 260 mc; input impedance, 5 k ohms; peak deviation, ±150 kc maximum, 125 kc nominal; power requirements, 28 v. Vector Mfg. Co., Inc., Keystone Rd., Southampton, Pa.

Aerodynalog: Virtually all fundamental aerodynamic and hydrodynamic phenomena may be studied by use of the Aerodynalog. Subsonic, transonic, and supersonic gas flow-fields are reproduced with high fidelity. Good wind-tunnel simulation is achieved for over-all disturbance patterns as well as quantitative measurements. Shock waves are vividly projected by the optical system. Amrad, Inc., Sewanee, Tenn.

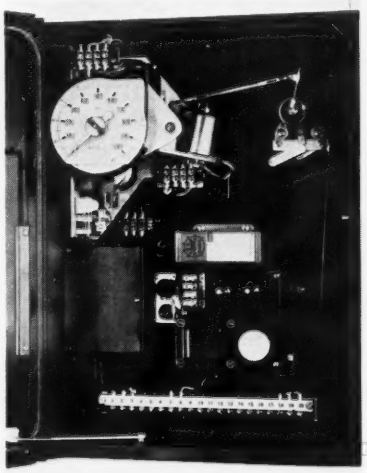
Proximity Switch: Designed for use as a limit, interlock, counter or indicator sensor, this switch operates under unfavorable environments, such as those created by oil, grit, vibration, or sludge. The switch consists of a sensor and a separate transistorized amplifier with plug-in key. Adjustable sensitivity range, $^1/_8$ to $^1/_2$ in. Operates off 115 v, 60 cycle power. Micro Switch, Freeport, Ill.



Absolute Pressure Regulator: Series 141RR2 regulator (weight 1 lb; length, 6.1 in.; diam, 2 in., with an 0.6 in. extension for the outlet port) maintains pressure in missile pneumatic systems to within $^1/_2$ lb/sq in. over normal flow ranges and within $^1/_4$ lb over altitudes ranging from sea level to 90,000 ft. Units are operable with air pressures ranging from 14.7 to 315 psi absolute. Consolidated Controls Corp., Bethel, Conn.

Two-Axis Free Gyro: Equipped with a synchrotype pickoff on the outer gimbal, the 3417 Gyro, suitable for missile guidance, measures 4 x 2.75 in. and weighs less than 2.5 lb. It will withstand 40-g acceleration and shock. Mechanical caging is actuated by a push-rod extending externally through the base. Both gimbals can be uncaged simultaneously in 0.1 sec. Giannini Controls Corp., 918 E. Green St., Pasadena, Calif.

Eectronic Transducer: The Dyna-Servo is a high-torque transducer for converting measurements of pressure, liquid level, mechanical motion, etc. into a shaft position. The shaft may operate transmitting slidewires, alarm switches, analog-to-digital encoders, deviation contacts, etc. The balancing system uses an amplifier to operate a balancing motor which provides precise positioning. The Bristol Co., Waterbury 20, Conn.

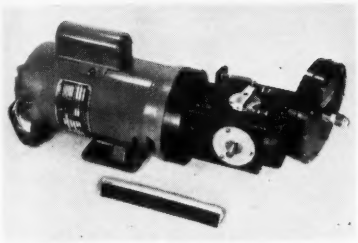


Line Scan Tube Is Key to Reconnaissance Unit

Exploded view of new Line Scan Tube shows phosphor-coating rotating anode, which spins at 1600 rpm, and special vacuum bearings. Photoscan provides extremely fine spot of high brilliant light along a single line about $2^1/_4$ in. long.

A system of instantaneous transmission of aerial photos without loss of detail has been developed at CBS Laboratories to meet military requirements of Space Age reconnaissance. Called Photoscan, the device transmits pictures from the reconnaissance area over hundreds of miles in about 3 sec. Its range can be increased by adding one or more relay links. Eventually, the company noted, the system may be adapted to upper-altitude and space-probe communications.

Basically, Photoscan consists of an airborne scanner, weighing about 70 lb, and ground receiving equipment. Its high picture resolution is due to a unique T-shaped line scan tube whose fine spot of light scans back and forth along a single line at a rate of 10,000 times per second. It can generate from 10 to 20 times greater brightness than conventional tubes; contains approximately 120 million picture elements against 250,000 for the sharpest TV picture; and has a lifetime of 1500 hours.

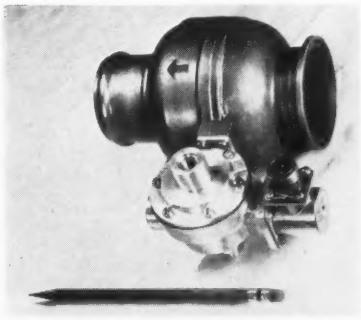


Variable-Speed Drive: For process-control applications, or for conversion from pneumatic to mechanical systems—the Servotran is available in many sizes from the $^1/_{1000}$- to $^1/_{100}$- hp range, up to $^1/_{10}$-hp. A $^1/_4$-hp model is made for smaller speed ranges. The drive is fitted with a diaphragm for vacuum or pressure control. A few in.-oz pressure on the control shaft changes speed. Humphrey, Inc., 2804 Canon St., San Diego 6, Calif.

Small Centrifuge: Gyrex G-Rater, a rotary centrifuge featuring moderate accuracy and low cost, operates up to 100 g in a number of standard speed ranges. Basic accuracy is better than 1 percent in terms of rpm. Two matched objects larger than 3-in. cube and 5-lb weight can be tested in three axes on the standard 12-in.-radii booms. The Gyrex Corp., 3003 Pennsylvania Ave., Santa Monica, Calif.

Displacement Transducers: Models DT500 and DT2000 measure linear displacement between 0.500 and 2 in., with a frequency response from 0 to 10,000 cps, dependent upon the Photocon Dynagage measuring system. Photocon Research Products, 421 N. Altadena Dr., Pasadena, Calif.

Pressure-Regulating Valve: A new Vap-Air valve suitable for missile applications weighs 2.6 lb and handles upstream pressures to 200 psi, with



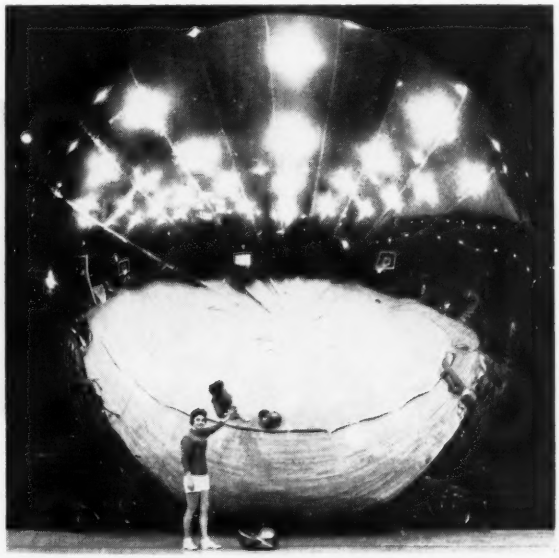
downstream regulation from 5 to 25 psi. Leakage is low, since it has a positive metal-to-metal seat. Pressure drop through the valve at 10-lb/min air flow is 1.4 in. Hg; at 25 lb/min, 612 in. Hg. Vapor Heating Corp., 6420 W. Howard St., Chicago 48, Ill.

High-Speed Framing Camera: This camera can be used in ordnance studies, shock wave studies, missile launching, and many other applications requiring high-speed photography. The electronic shutter has a speed range of 0.1 to 10 microsec. A separate shutter tube and objective lens is used for each exposure. Objective lens, 50-mm. F/1.4 Nikkor; recording lens, 75-mm F/1.9 Wollensak. Abtronics, Inc., Livermore, Calif.

Zoom Lens: Mark VI-M, a manually controlled zoom lens for vidicon cameras, has a zoom range of 6 to 1. Specifications are: Speed and focal length ranges, f/3.5, 25 to 150 mm; with optical extender, f/5.6, 40 to 210 mm. Resolution, 800 TV lines; dimensions, 2.5 x 2.5 x 6.5 in.; weight, 1.5 lb. A range extender and close-up lenses are available as optional accessories. Zoomar, Inc., Glen Cove, L.I., N.Y.

Dead-Weight Calibrators: Two series of calibrators are available to calibrate load cells or, in the field, to calibrate one or more of the six load components directly on an engine thrust-stand. One is a direct deadweight loader applying calibrated weights. The second employs a flexurally supported beam balance. Aeroscience, Inc., 3015 S. Kilson Dr., Santa Ana, Calif. ♦♦

Any One for Volleyball?



The pictured 30-ft. aluminized Mylar balloon, designed and built by the G. T. Schjedahl Co., will be put into a 1000-mile orbit for the purpose of making drag measurements when the first Transit satellite is launched sometime this spring. The balloon weighs 20 lb and packs in the canister shown in the foreground.

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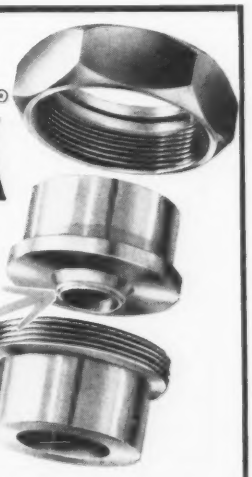

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